Section I—Air and Fallout

FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess human radiation exposure from fallout, it is widely used as the basis for alerting systems for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form and are also compared in beta concentration isograms.

1. Radiation Surveillance Network, October 1965

Division of Radiological Health, Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health which regularly gathers samples from 73 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Alerting Function

The alerting function of the network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the end of the sampling period to allow for decay of naturally-occurring radon daughters. The network station operators telephone any daily field estimates over 10 pc/m^3 to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C. Lower field estimates are reported to the Center by the laboratory at Rockville, Maryland, which receives a daily written report together with the air filter submitted by each station operator. The filters are counted at the laboratory to confirm field estimates. Analyses for specific radionuclides may also be made if gross beta activity concentrations are high. All field estimates are reported elsewhere on a monthly basis (*1*). When unusually high air levels are reported, appropriate Federal and State officials are promptly notified.

Air Sampling Procedure and Results

Airborne particulates are collected continuously on carbon-loaded cellulose dust filters 4 inches in diameter. A volume of about 1,800 cubic meters of air is drawn through each filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, where the gross beta activity is measured using a thin-window, gas-flow proportional counter, calibrated with a Sr^{90}–Y^{90}

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS

standard. Each filter is counted at least 3 days after the end of the sampling period and again 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. By using the two counts and the Way-Wigner formula (*2*), the age of fission products is estimated, and the activity extrapolated to the time of collection.[1] The daily concentrations and estimated ages of selected samples are reported by the PHS in a monthly RSN report (*1*).

Times profiles of gross beta activity in air for eight RSN stations are shown in figure 2.

Precipitation Measurements

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inch of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by:

$$D = \frac{CP}{1000}$$

where D is the deposition in nc/m^2, C is the concentration in pc/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month, and the average concentration for the month, $\overline{C}$, is determined by:

$$\overline{C} = \frac{\Sigma D}{\Sigma P} \times 1000$$

The October 1964 average concentrations and total depositions are given in table 1.

[1] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value; consequently, the calculated age will be overestimated.

TABLE 1.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, OCTOBER 1964

Station location		Air surveillance					Precipitation measurements	
		Number of samples	Gross beta activity (pc/m³)			Last profile in *RHD*	Total Depth (mm)[b]	Total deposition (nc/m²)[b]
			Maximum	Minimum	Average[a]			
Ala:	Montgomery	26	8.61	<0.10	1.29	Aug 64	162.4	32.6
Alaska:	Adak	25	0.52	<0.10	<0.19	Nov 64		
	Anchorage	31	0.69	<0.10	<0.19	Jul 64	43.2	9.0
	Attu	31	0.51	<0.10	<0.16	Dec 64		
	Fairbanks	27	2.82	<0.10	<0.24	Aug 64	17.0	35.3
	Juneau	12	1.06	<0.10	<0.21	Sep 64	26.3	40.5
	Kodiak	27	1.01	<0.10	<0.14	Oct 64		
	Nome	24	0.33	<0.10	<0.12	Feb 64		
	Point Barrow	17	5.69	<0.10	0.81	Jan 65		
	St. Paul Island	29	0.26	<0.10	<0.13	Mar 64		
Ariz:	Phoenix	21	1.69	0.18	0.66	Sep 64		
Ark:	Little Rock	26	2.82	0.16	0.77	Sep 64	7.6	1.5
Calif:	Berkeley	31	0.87	<0.10	0.25	Oct 64	34.6	15.7
	Los Angeles	31	0.75	<0.10	0.25	Feb 64	8.9	2.8
Canal Zone:	Ancon	18	0.26	<0.10	<0.10	Nov 64		
Colo:	Denver	29	20.07	0.16	2.68	Oct 64	5.2	1.0
Conn:	Hartford	30	5.45	0.13	0.72	Oct 64	44.3	11.1
Del:	Dover	21	7.59	<0.10	0.96	Aug 64		
D. C:	Washington	31	9.01	<0.10	1.04	Apr 64	34.6	9.0
Fla:	Jacksonville	29	9.65	<0.10	1.59	Sep 64	109.6	39.2
	Miami	28	15.99	<0.10	2.87	Oct 64	203.8	84.3
Ga:	Atlanta					Jul 64	147.5	29.5
Guam:	Agana	31	1.14	<0.10	<0.17	Apr 64		
Hawaii:	Honolulu	31	8.70	<0.10	1.14	Feb 64	29.4	17.7
Idaho:	Boise	26	10.71	0.24	1.63	Dec 64	8.7	3.5
Ill:	Springfield	31	2.87	0.13	0.60	Mar 64		
Ind:	Indianapolis	24	2.00	<0.10	0.53	Jul 64	13.6	3.6
Iowa:	Iowa City	31	1.06	<0.10	0.39	Nov 64		
Kans:	Topeka	25	1.94	<0.10	0.35	Jul 64	5.0	2.7
Ky:	Frankfort	31	4.89	<0.10	0.77	Feb 64	15.1	15.6
La:	New Orleans	29	6.07	<0.10	0.85	Mar 64	72.9	42.6
Maine:	Augusta	30	5.21	<0.10	0.82	Mar 64	89.6	35.6
	Presque Isle	22	3.63	<0.10	0.45	Nov 64	17.0	23.9
Md:	Baltimore	26	6.49	<0.10	0.75	Oct 64	19.9	4.0
	Rockville	19	9.63	<0.10	0.86	Mar 64		
Mass:	Lawrence	31	7.25	<0.10	0.87	Aug 64	38.7	17.5
	Winchester	29	4.45	<0.10	0.73	Apr 64	52.5	15.6
Mich:	Lansing	31	2.78	0.14	0.72	Feb 64	19.2	15.5
Minn:	Minneapolis	26	1.40	<0.10	0.27	Mar 64	12.1	5.1
Miss:	Jackson	27	5.81	<0.10	1.26	Apr 64	96.9	37.7
	Pascagoula	21	15.68	<0.10	1.42	Dec 64		
Mo:	Jefferson City	27	1.05	0.11	0.36	Jul 64	5.3	2.8
Mont:	Helena	31	28.90	<0.10	2.46	Nov 64	0.63	0.70
Nebr:	Lincoln	17	4.10	<0.10	<0.43	Apr 64		
Nev:	Las Vegas	30	24.62	<0.10	2.09	Aug 64		
N. H:	Concord	18	6.26	<0.10	0.88	Feb 64		
N. J:	Trenton	30	7.21	<0.10	0.76	Mar 64	10.4	2.0
N. Mex:	Santa Fe	27	10.49	0.21	1.56	Nov 64		
N. Y:	Albany	25	8.47	<0.10	0.84	Jul 64	13.5	3.1
	Buffalo	19	4.21	0.18	0.70	Nov 64		
	New York	31	7.84	<0.10	0.91	Dec 64		
N. C:	Gastonia	28	6.55	<0.10	0.95	Nov 64	158.6	33.0
N. Dak:	Bismarck	30	13.96	<0.10	1.02	Feb 64	2.6	4.7
Ohio:	Cincinnati	23	3.89	0.16	0.68	Aug 64		
	Columbus	30	4.57	<0.10	0.69	Apr 64	10.2	9.5
	Painesville	30	5.02	<0.10	0.89	Oct 64	60.2	34.5
Okla:	Oklahoma City	30	2.79	<0.10	0.53	Apr 64		
	Ponca City	29	0.82	<0.10	0.27	Oct 64	50.2	30.7
Ore:	Portland	30	8.21	0.11	0.95	Oct 63	35.2	8.2
Pa:	Harrisburg	29	8.07	<0.10	0.77	Jul 64	12.3	2.5
P. R:	San Juan	31	0.37	<0.10	<0.14	Mar 64	22.6	4.5
R. I:	Providence	31	3.85	<0.10	0.56	Jan 64	62.3	12.5
S. C:	Columbia	27	7.41	<0.10	0.71	Dec 64	310.5	62.2
S. Dak:	Pierre	31	17.07	<0.10	1.18	Sep 64		
Tenn:	Nashville	31	2.77	0.13	0.75	Jan 64	37.1	21.7
Tex:	Austin	30	3.62	<0.10	0.52	Aug 64	52.5	10.5
	El Paso	31	6.38	0.12	0.89	Jan 64	6.7	1.4
Utah:	Salt Lake City	29	22.50	<0.10	2.57	Aug 63	15.9	4.7
Vt:	Barre	29	6.31	0.12	0.91	Sep 64	43.7	27.7
Va:	Richmond	31	7.04	<0.10	0.99	Sep 64	69.0	14.3
Wash:	Seattle	30	1.03	<0.10	0.21	Jul 64	17.4	3.6
	Spokane	30	10.87	<0.10	0.66	New		
W. Va:	Charleston	31	6.27	0.12	0.82	Dec 64	9.1	6.0
Wis:	Madison	30	1.55	<0.10	0.53	Sep 64	3.5	3.6
Wyo:	Cheyenne	31	12.84	0.12	1.89	Aug 64		
Network summary[d]		2,032	28.9	<0.10	0.82		46.9	17.1

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign appears before the average.

[b] Blank indicates no report received.

[c] Station added to network September 1964.

[d] For the network summary, all averages are the arithmetic average of the station averages.

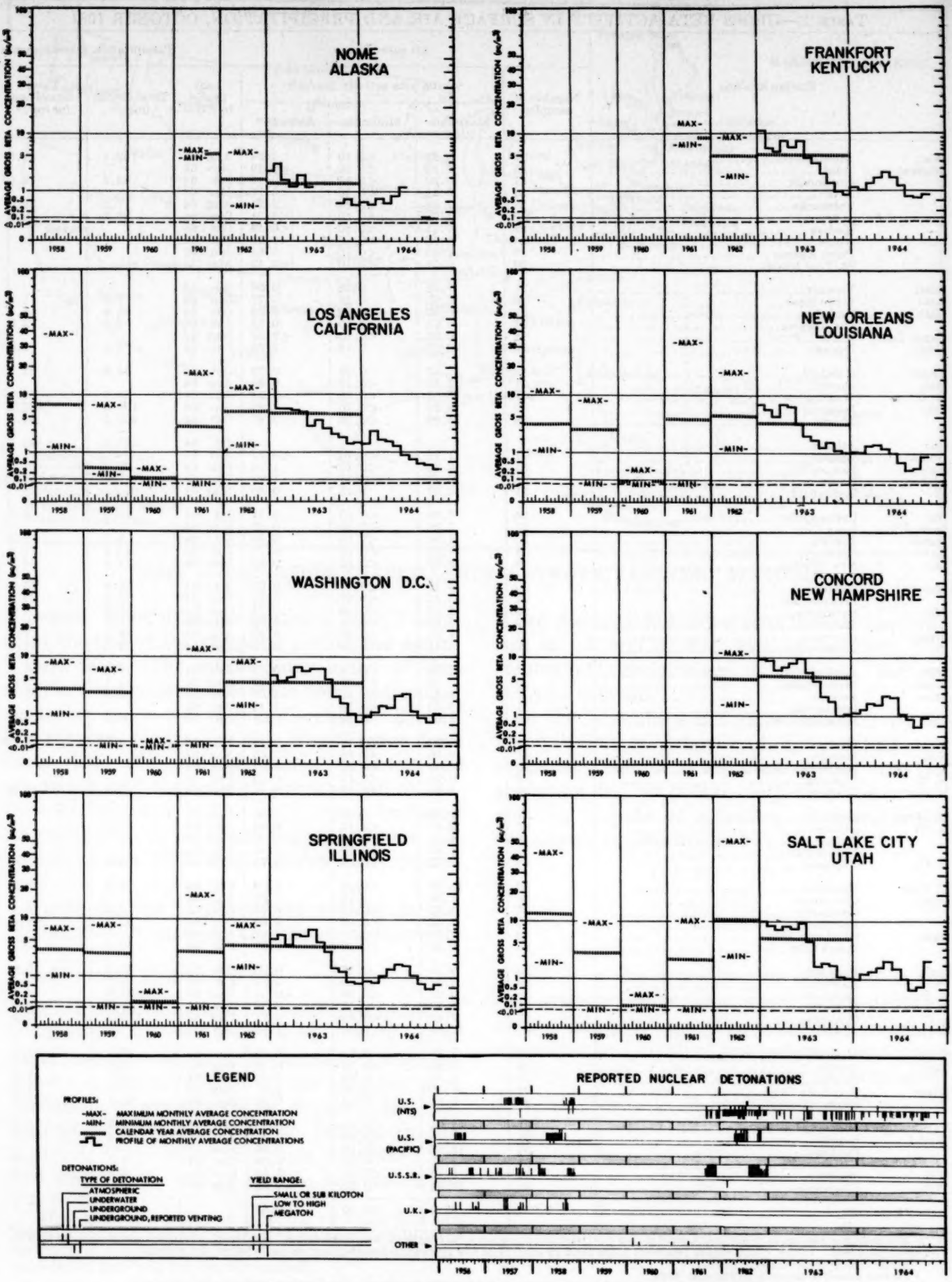

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR—RADIATION SURVEILLANCE NETWORK, 1958–OCTOBER 1964

Significant increases over the previous month in both the maximum and average air concentrations are observed in the data presented. These increases are presumably the result of nuclear testing conducted by Mainland China on October 16, 1964. More detailed discussions concerning the detection of nuclear debris from Chinese tests are presently being prepared.

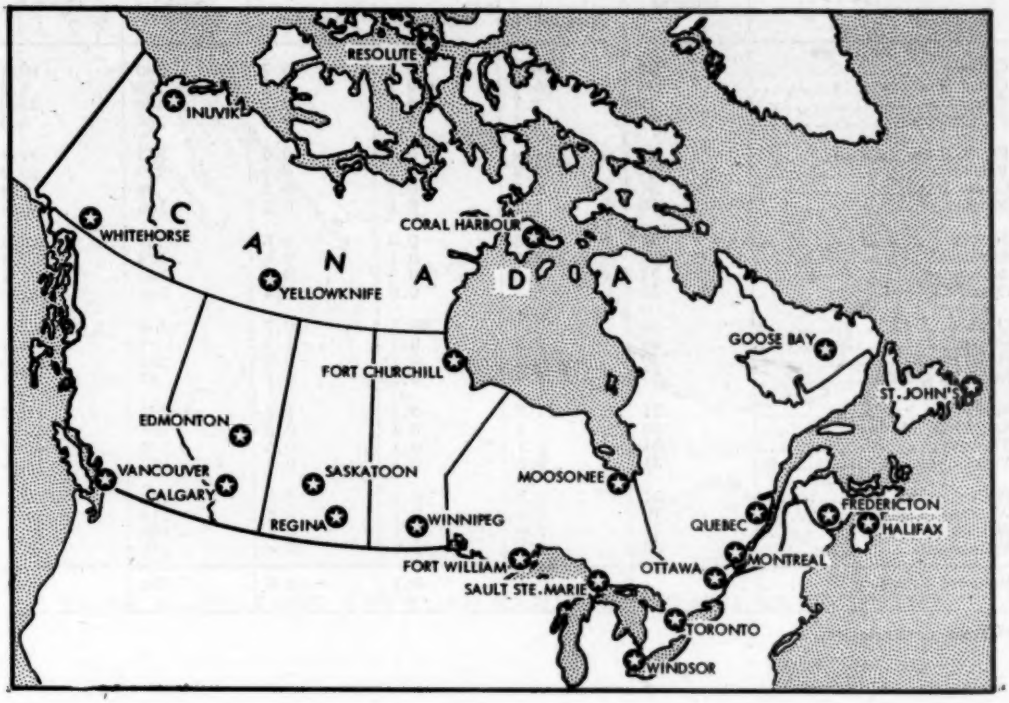

FIGURE 3.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS

2. Canadian Air Monitoring Program[2] October 1964

Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas-flow, Geiger-Mueller counter system calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for October 1964 are given in table 2 and presented in conjunction with U.S. and Mexican data by an isogram map (figure 5).

[2] Data from RADIATION PROTECTION DIVISION. *Radiation Protection Programs*, Vol. 2, No. 11: 11–24 (November 1964), Canadian Department of National Health and Welfare, Ottawa, Canada.

TABLE 2.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, CANADA, OCTOBER 1964

Station location	Air surveillance				Precipitation Measurements	
	Number of samples	Gross beta activity (pc/m³)			Average concentration (pc/liter)	Total deposition (nc/m²)
		Maximum	Minimum	Average		
Calgary	30	49.2	0.1	3.7	890	16.1
Coral Harbour	30	0.4	0.1	0.2	128	1.9
Edmonton	29	5.7	0.1	2.1	3,466	22.0
Ft. Churchill	14	1.5	0.1	0.3	358	4.0
Ft. William	31	6.8	0.1	0.9	853	24.7
Fredericton	31	3.9	0.1	0.5	230	15.2
Goose Bay	31	0.8	0.1	0.2	89	9.8
Halifax	29	1.2	0.1	0.3	165	20.0
Inuvik	31	4.8	0.0	0.6	361	12.6
Montreal	31	3.5	0.1	0.6	338	14.8
Moosonee	31	7.2	0.1	0.8	240	13.4
Ottawa	31	3.1	0.0	0.4	330	10.2
Quebec	31	5.5	0.1	0.7	709	42.1
Regina	31	5.0	0.1	1.5	**	3.6
Resolute	30	0.3	0.1	0.2	254	11.6
St. John's, Nfld	31	0.9	0.1	0.3	91	19.2
Saskatoon	31	11.2	0.1	1.3	1,673	17.8
Sault Ste. Marie	30	1.4	0.1	0.5	167	10.7
Toronto	31	1.8	0.1	0.5	1,166	45.3
Vancouver	31	4.6	0.1	0.4	272	11.6
Whitehorse	31	4.3	0.1	0.5	456	7.1
Windsor	29	3.9	0.1	0.7	1,219	24.4
Winnipeg	31	7.0	0.1	0.8	4,182	24.4
Yellowknife	30	6.1	0.0	0.4	171	4.4
Network summary		6.7	0.1	0.8	774	16.1

** Trace precipitation.

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are also added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is ignited together with the polyethylene liner at 450 degrees C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infra-red lamp, and then counted with a thin-end-window Geiger-Mueller counter calibrated with a Sr^{90}–Y^{90} source. Gross beta activities for October 1964 samples are given in table 2. Radionuclide analyses are reported quarterly in *RHD*.

3. Mexican Air Monitoring Program October 1964

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), Mexico City. From 1952 to 1961 the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*8–12*).

In 1961 the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance network. This network consists of 17 stations (see figure 4), twelve of which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRP operate the station at Mexico City, while the other four stations are manned by members of the Centro de Previsión

FIGURE 4.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week at the rate of approximately 1,200 cubic meters per day, through a high-efficiency, 6 x 8-inch glass fiber filter, using high volume samplers. After each 24 hour sampling period, the filter is removed and forwarded via air mail to the "Laboratorio de Estudios sobre Contaminación Radiactiva", CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughter natural radioactivity. Data are not extrapolated to time of collection.

Results

The maximum, minimum, and average fission product beta concentrations in surface air during October 1964 are presented in table 3. The data are also represented in the beta activity isogram map of North America, figure 5.

TABLE 3.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO 1964

Station	Number of Samples	Gross beta activity (pc/m³)		
		Maximum	Minimum	Average
Acapulco	12	0.4	<0.1	0.1
Ciudad Juárez	15	3.4	<0.1	0.5
Chihuahua	18	0.3	<0.1	0.2
Ensenada	10	0.3	<0.1	0.2
Guadalajara	8	0.3	<0.1	0.1
Guaymas	20	0.4	<0.1	0.2
La Paz	17	0.2	<0.1	0.1
Matamoros	8	0.4	<0.1	0.3
Mazatlán	28	0.5	<0.1	0.1
Mérida	14	3.9	<0.1	1.4
México, D.F.	17	0.7	<0.1	0.2
Nuevo Laredo	12	2.6	0.2	0.7
San Luis Potosí	20	5.9	<0.1	0.7
Tampico	22	1.3	0.1	0.3
Torreón	25	2.8	<0.1	0.5
Tuxtla Gutiérrez *				
Veracruz	24	3.2	<0.1	0.6

* Blank indicates station temporarily shut down.

4. Pan American Air Sampling Program October 1964

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by four countries in the Americas under the auspices of a collaborative program, developed by the Pan American Health Organization and the Public Health Service (PHS), for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The four air sampling stations included in the Program are operated by the technical staff of the Ministry of Health in each country. The station in Kingston, Jamica, is operated by the Public General Hospital; in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations; in Lima, Peru, by the Institute of Occupational Health; and in Santiago, Chile, by the Occupational Health Service. The Kingston station began operation in March 1964, and the other three were started near the end of 1962.

The October 1964 air monitoring data from the four participating countries are given in table 4.

TABLE 4.—GROSS BETA ACTIVITY IN AIR, OCTOBER 1964

[Concentrations in pc/m³]

Sampling stations	No. of samples	Maximum	Minimum	Average *
Kingston, Jamaica	14	0.21	<0.10	<0.11
Caracas, Venezuela	21	0.15	<0.10	<0.10
Lima, Peru	19	0.25	<0.10	<0.13
Santiago, Chile	30	0.37	<0.10	<0.14

* The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed in front of the average.

5. Gross Beta Activity in Air, North America October 1964

Beginning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America. The data from the Radiation Surveillance Network and the Canadian Air Network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*13*).

With the formation of the Mexican Air monitoring program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, Pan American Air Sampling Program, National Air Sampling Network, the HASL 80th Meridian Network, and the Mexican Network (*14*). The new intercalibration factors reflect some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963.

Figure 5 shows the October 1964 activity in air throughout North America based on the data from the Canadian Air Monitoring Program, the Radiation Surveillance Network, the Pan American Air Sampling Program, and the Mexican Air Monitoring program. An intercalibration factor of 1.28 was applied to the RSN and Pan American data and the Mexican data were multiplied by 0.81 in order to adjust them to Canadian data.

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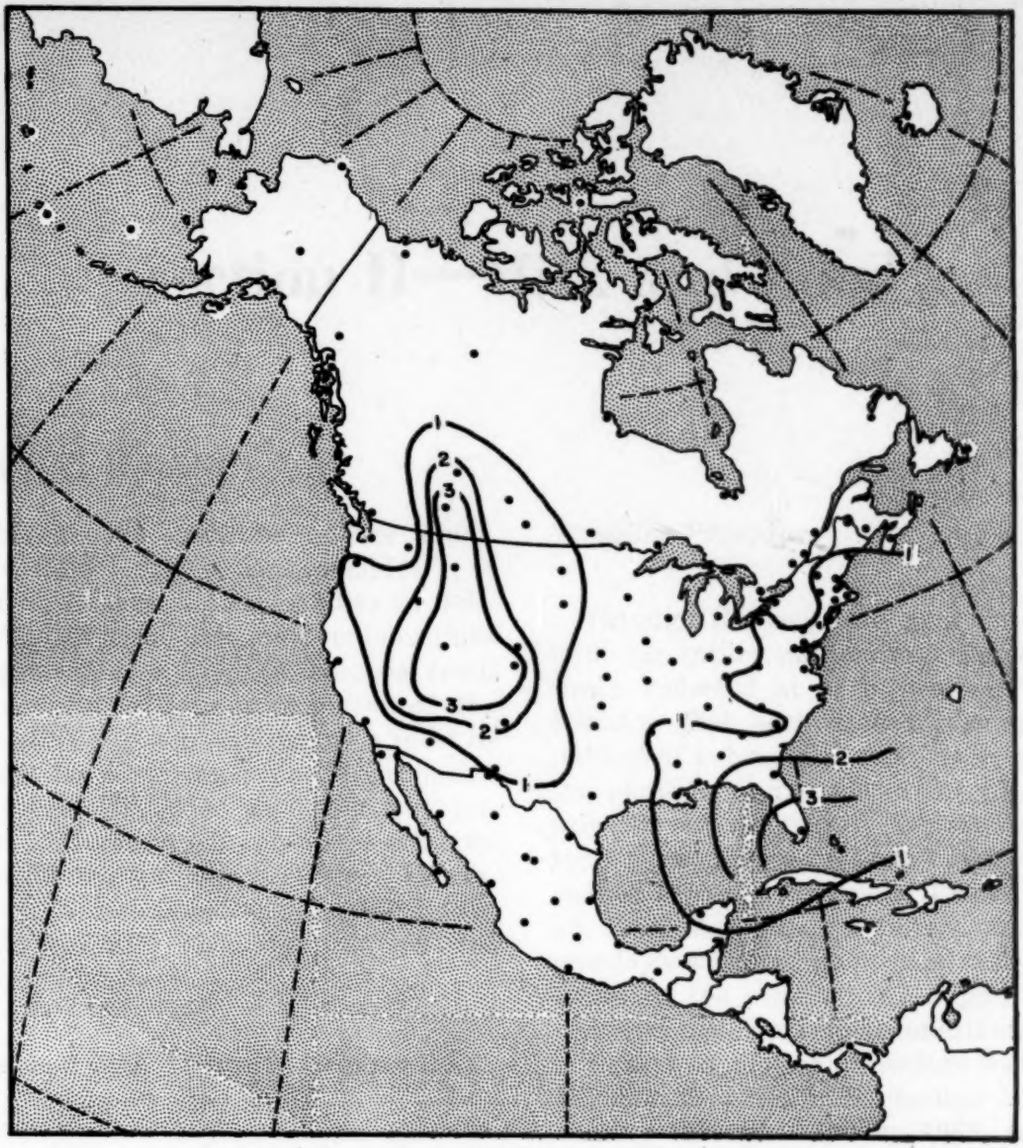

FIGURE 5.—ISOGRAM OF AVERAGE GROSS BETA CONCENTRATIONS IN AIR, NORTH AMERICA, OCTOBER 1964

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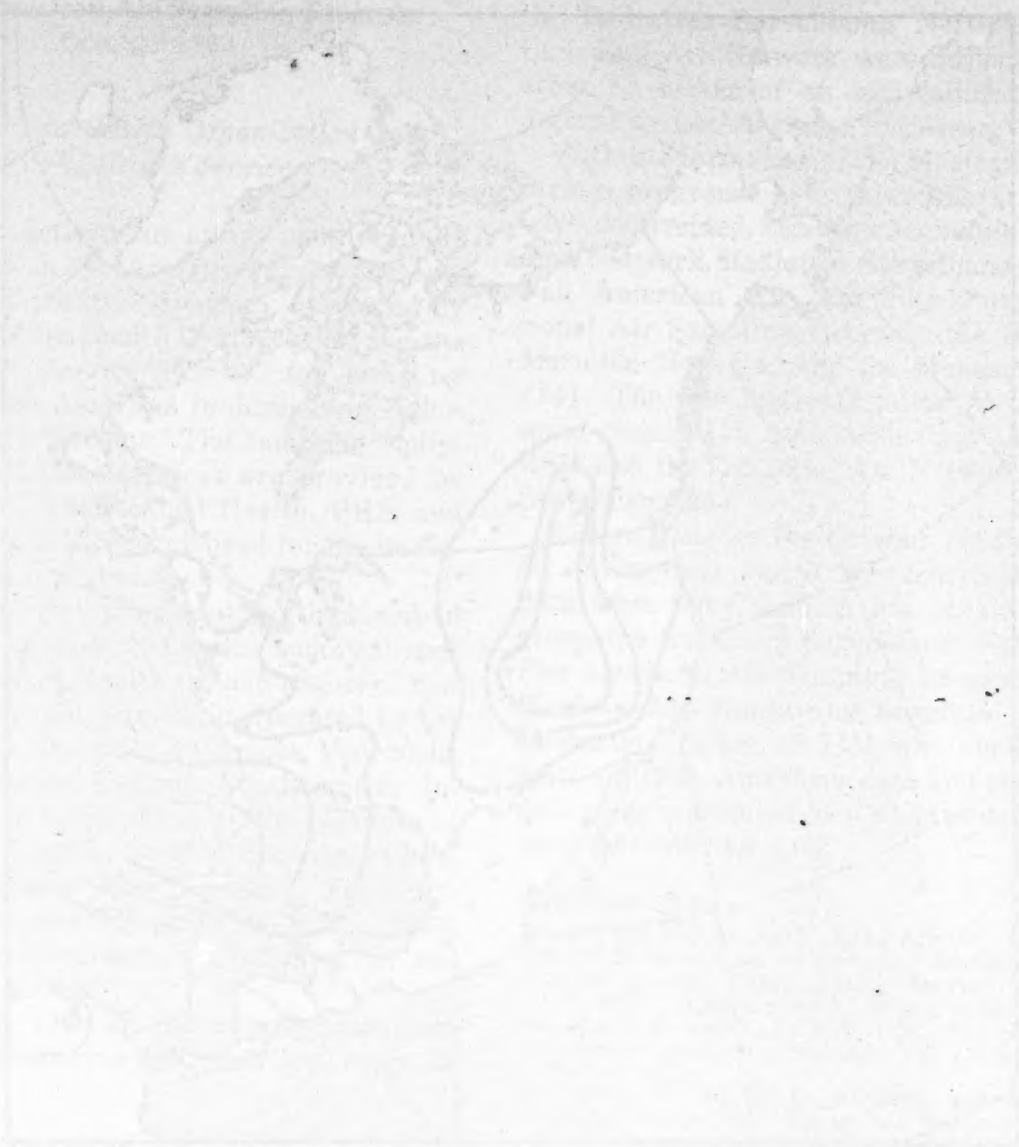

Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, October 1964

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of the raw milk network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network, which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

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Sampling Procedure

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each station. The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Samples are preserved with formaldehyde and are sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NERHL), for analysis. Gamma analyses for iodine–131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after monthly samples are received by the laboratories; publication in *RHD* follows 3 to 4 months after the monthly samples are composited for analyses.

Analytical Procedures

Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma scintillation spectroscopy.[1] After the weekly samples are gamma scanned, samples from two consecutive weeks are composited and analyzed radiochemically for strontium–89 and strontium–90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH ESTIMATED CONCENTRATIONS FOR SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error [a] (pc/liter)	Estimated concentration (pc/liter)	Error [a] (percent of concentration)
Iodine-131	0 to 100	±10	100 or greater	±10
Barium-140	0 to 100	±10	100 or greater	±10
Cesium-137	0 to 100	±10	100 or greater	±10
Strontium-89	0 to 50	±5	50 or greater	±10
Strontium-90	0 to 20	±2	20 or greater	±10

[a] Two standard deviations (2σ).

The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Cs^{137}, 10; Ba^{140}, 10; and I^{131}, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method, while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium–40 concentrations[2] determined from the gamma spectrum.

Data Presentation

Table 2 presents summaries of the analyses for the month of October 1964 (actual reporting period September 27–October 31, 1964). Although not shown in table 2, barium–140 monthly average concentrations in milk were less than 10 pc/liter. Radionuclide values reported by a laboratory as being below the minimum detectable concentration have been averaged by using one-half the minimum detectable value. The averaging procedure was modified for iodine–131 and barium–140 in October 1963 when nondetectable concentrations of these radionuclides were considered zero. A similar procedure is used for the network average.

Figures 1 and 2 are isogram maps showing the estimated strontium–90 and cesium–137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations. Additional modifications to the isograms are made according to available information on milksheds.

In order to develop the distribution of the network's stations *versus* radionuclide concentrations in milk, tables 3 and 4 have been prepared from the monthly averages shown in table 2.

The average monthly strontium–90 concentrations in pasteurized milk from selected cities in the sampling program are presented in figure 3.

Each graph shows the strontium–90 concentrations in milk from one city in each of the four U.S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network three times a year. The last column in table 2 shows the most recent issue in which a graph of the

[2] The conversion factor is 1.18×10^{-3} g K/pc K^{40}.

TABLE 2.—RADIOACTIVITY IN PASTEURIZED MILK, OCTOBER 1964

[Average radioactivity concentrations in pc/liter]

Sampling locations		Calcium (gm/liter)		Strontium-89 (pc/liter)		Strontium-90 (pc/liter)		Cesium-137 (pc/liter)		Iodine-131 (pc/liter)		Barium-140 (pc/liter)	
		Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month
Ala:	Montgomery	1.17	1.15	<5	<5	21	18	65	60	0	0	0	0
Alaska:	Palmer	1.17	1.20	<5	<5	16	19	105	85	0	0	0	0
Ariz:	Phoenix	1.15	1.19	<5	<5	3	5	25	20	0	0	0	0
Ark:	Little Rock	1.15	1.16	<5	5	38	34	80	65	0	0	0	0
Calif:	Sacramento	1.26	1.20	<5	<5	6	6	30	20	0	0	0	0
	San Francisco	1.22	1.20	<5	<5	7	11	35	20	0	0	0	0
C. Z:	Cristobal	1.11	1.12	<5	<5	5	5	50	55	0	0	0	0
Colo:	Denver	1.25	1.26	<5	<5	20	17	100	75	0	0	0	0
Conn:	Hartford	1.10	1.11	<5	<5	19	14	110	75	0	0	0	0
Del:	Wilmington	1.15	1.17	<5	<5	20	14	85	65	0	0	0	0
D. C:	Washington	1.11	1.12	<5	<5	19	18	65	50	0	0	0	0
Fla:	Tampa	1.19	1.16	<5	<5	17	16	255	225	0	0	0	0
Ga:	Atlanta	1.17	1.18	<5	5	28	24	105	90	0	0	0	0
Hawaii:	Honolulu	1.19	1.21	<5	10	11	15	70	70	0	0	0	0
Idaho:	Idaho Falls	1.24	1.22	<5	<5	25	14	110	60	0	0	0	0
Ill:	Chicago	1.14	1.15	<5	<5	19	15	85	70	0	0	0	0
Ind:	Indianapolis	1.15	1.18	<5	<5	18	14	70	55	0	0	0	0
Iowa:	Des Moines	1.21	1.23	<5	<5	22	19	70	45	0	0	0	0
Kans:	Wichita	1.17	1.24	<5	<5	18	16	50	45	0	0	0	0
Ky:	Louisville	1.13	1.15	<5	<5	27	22	50	45	0	0	0	0
La:	New Orleans	1.19	1.21	<5	<5	48	39	115	90	0	0	0	0
Maine:	Portland	1.14	1.15	<5	<5	29	22	175	135	0	0	0	0
Md:	Baltimore	1.13	1.13	<5	<5	21	18	70	50	0	0	0	0
Mass:	Boston	1.13	1.15	<5	<5	31	21	180	105	0	0	0	0
Mich:	Detroit	1.14	1.16	<5	<5	16	16	90	70	0	10	0	0
	Grand Rapids	1.15	1.21	<5	<5	19	18	100	85	0	0	0	0
Minn:	Minneapolis	1.21	1.25	<5	10	27	24	115	70	0	0	0	0
Miss:	Jackson	1.21	1.19	<5	<5	37	33	85	65	0	0	0	0
Mo:	Kansas City	1.19	1.21	<5	<5	26	21	55	35	0	0	0	0
	St. Louis	1.20	1.24	<5	<5	21	17	55	45	0	0	0	0
Mont:	Helena	1.20	1.25	<5	<5	20	15	115	85	0	10	0	0
Nebr:	Omaha	1.21	1.23	<5	<5	24	19	70	45	0	0	0	0
Nev:	Las Vegas	1.19	1.18	<5	<5	6	7	50	35	0	10	0	0
N. H:	Manchester	1.17	1.20	<5	<5	30	23	205	140	0	0	0	0
N. J:	Trenton	1.12	1.12	<5	<5	18	14	85	65	0	0	0	0
N. Mex:	Albuquerque	1.19	1.22	<5	<5	9	9	45	35	0	10	0	0
N. Y:	Buffalo	1.09	1.09	<5	<5	18	14	105	80	0	0	0	0
	New York	1.09	1.14	<5	<5	25	18	120	85	0	0	0	0
	Syracuse	1.12	1.11	<5	<5	15	15	80	80	0	0	0	0
N. C:	Charlotte	1.17	1.19	<5	<5	38	34	100	70	0	0	0	0
N. Dak:	Minot	1.22	1.18	10	<5	49	39	145	100	0	0	0	0
Ohio:	Cincinnati	1.17	1.21	<5	<5	19	16	60	50	0	0	0	0
	Cleveland	1.12	1.21	<5	<5	19	17	90	65	0	0	0	0
Okla:	Oklahoma City	1.12	1.12	<5	<5	19	17	50	45	0	0	0	0
Ore:	Portland	1.24	1.29	<5	<5	30	22	165	85	0	0	0	0
Pa:	Philadelphia	1.11	1.19	<5	<5	18	15	80	70	0	0	0	0
	Pittsburgh	1.14	1.20	<5	<5	29	21	120	80	0	0	0	0
P. R:	San Juan	1.15	1.12	<5	<5	12	11	70	55	0	0	0	0
R. I:	Providence	1.13	1.18	<5	<5	23	19	140	95	0	0	0	0
S. C:	Charleston	1.15	1.14	<5	<5	31	31	110	95	0	0	0	0
S. Dak:	Rapid City	1.19	0.98	<5	<5	43	28	125	100	0	0	0	0
Tenn:	Chattanooga	1.20	1.18	<5	<5	39	33	90	65	0	0	0	0
	Memphis	1.16	1.16	<5	<5	28	27	55	40	0	0	0	0
Tex:	Austin	1.11	1.12	<5	<5	7	7	35	20	0	0	0	0
	Dallas	1.14	1.15	<5	<5	17	14	45	30	0	0	0	0
Utah:	Salt Lake City	1.27	1.41	<5	<5	25	18	165	90	0	0	0	0
Vt:	Burlington	1.13	1.16	<5	<5	25	19	140	90	0	10	0	0
Va:	Norfolk	1.13	1.17	<5	5	23	23	75	65	0	0	0	0
Wash:	Seattle	1.23	1.22	5	<5	28	16	170	105	0	0	0	0
	Spokane	1.22	1.28	<5	<5	26	23	130	85	0	0	0	0
W. Va:	Charleston	1.13	1.12	<5	<5	24	19	50	40	0	0	0	0
Wis:	Milwaukee	1.19	1.23	<5	<5	14	14	95	80	0	0	0	0
Wyo:	Laramie	1.18	1.22	<5	<5	20	14	105	60	0	0	0	0
Network average		1.17	1.18	<5	<5	22.3	18.7	94	69	0	<10	0	0

strontium–90 concentration was given for each station. A tabulation of the network monthly maximum, minimum, and average radionuclide concentrations in milk was given for March 1960–March 1964 in the July 1964 issue of *RHD* (*2*).

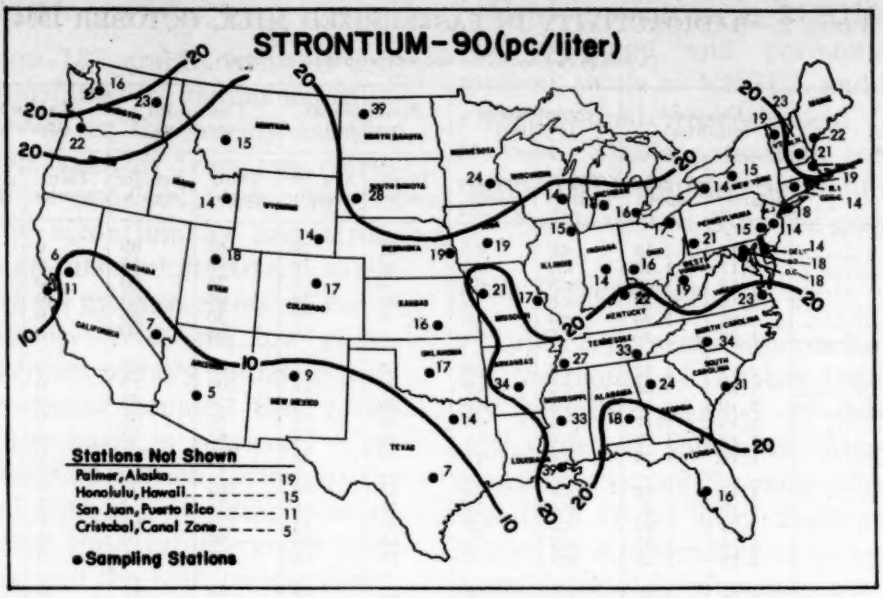

FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, OCTOBER 1964

TABLE 3.—RANGES OF STATION MONTHLY AVERAGES, FOR STRONTIUM-90, MAY-OCTOBER 1964

Range (pc/liter)	Number of stations in range, 1964					
	May	June	July	Aug.	Sept.	Oct.
Under 10	3	4	6	7	8	6
10–19	8	6	6	23	27	37
20–29	20	23	29	23	20	13
30–39	20	17	14	6	6	7
40–49	6	10	4	4	2	0
50–59	4	2	1	0	0	0
60–69	1	0	2	0	0	0
70–79	1	1	0	0	0	0

TABLE 4.—RANGES OF STATION MONTHLY AVERAGES FOR CESIUM-137, MAY-OCTOBER 1964

Range (pc/liter)	Number of stations in range, 1964					
	May	June	July	Aug.	Sept.	Oct.
Under 50	2	1	4	6	14	16
50–99	16	19	24	30	33	40
100–149	17	24	21	19	13	6
150–199	23	13	8	6	2	0
200–249	3	4	3	1	1	1
250–299	2	2	2	1	0	0

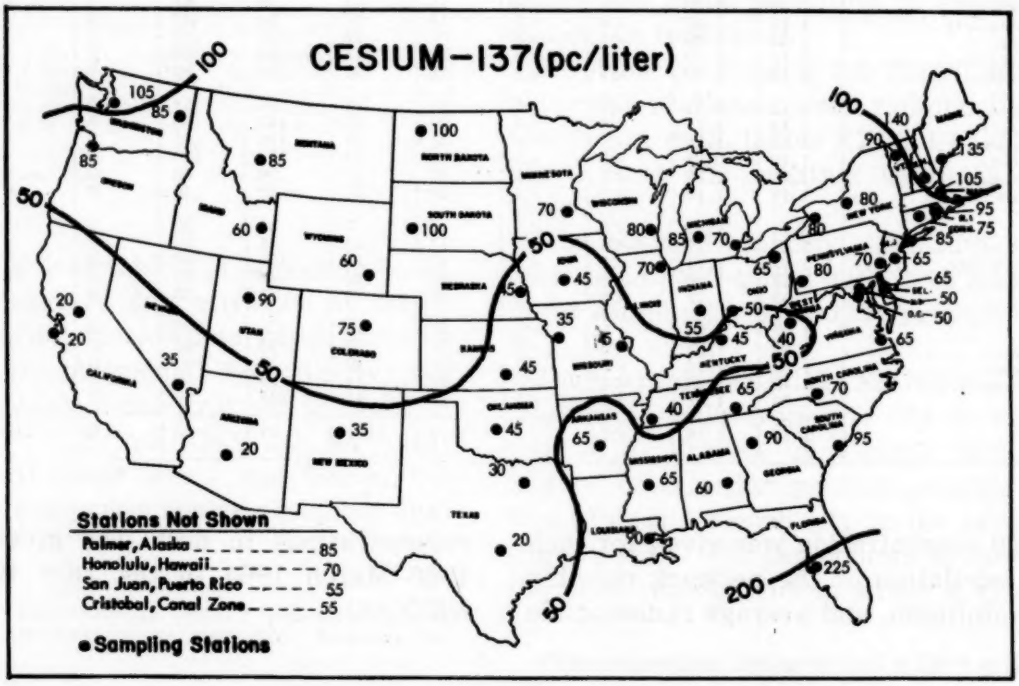

FIGURE 2.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK, OCTOBER 1964

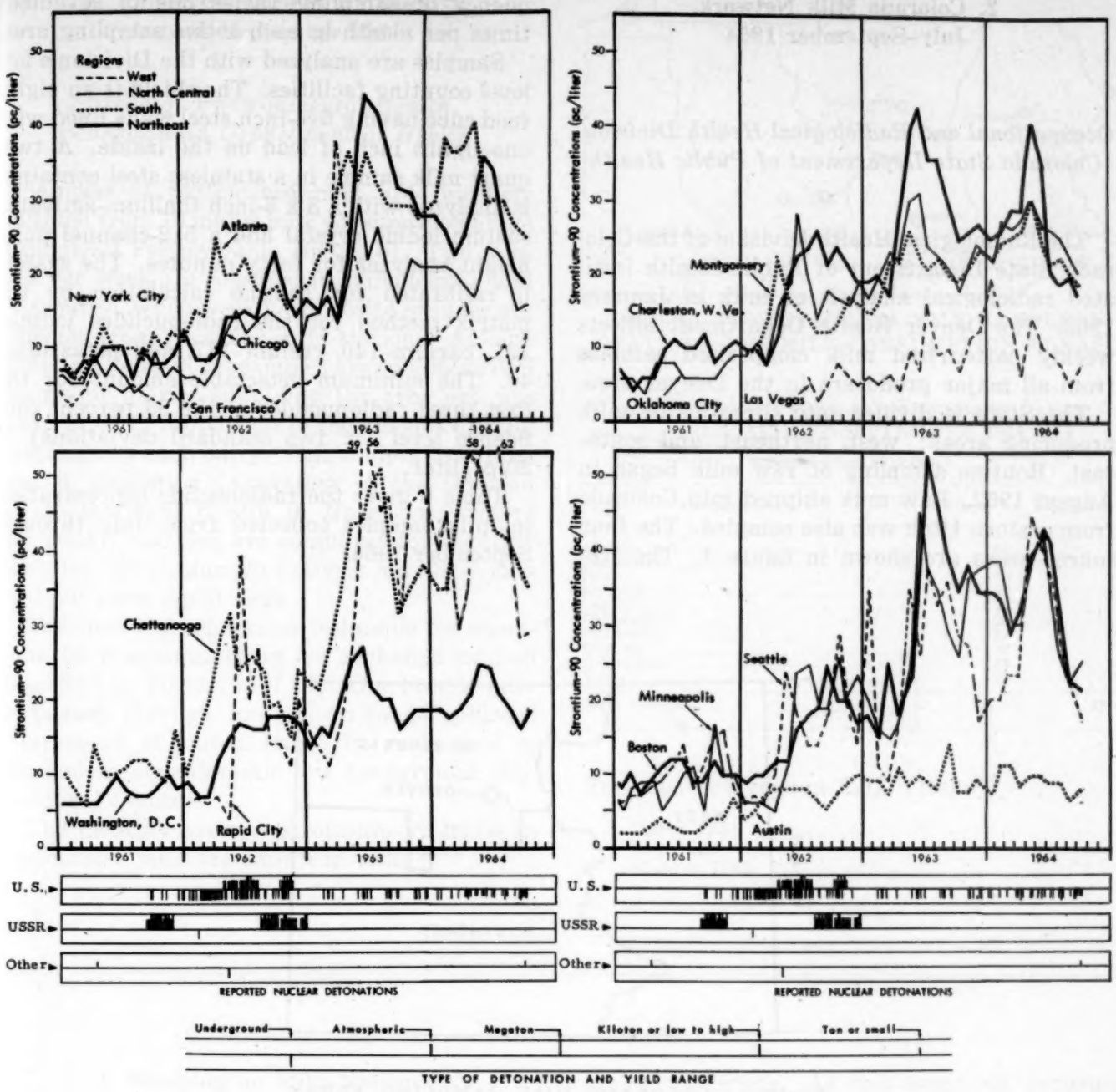

FIGURE 3.—STRONTIUM-90 IN PASTEURIZED MILK, 1961–OCTOBER 1964

Correction for January 1965 Issue

In figure 2 on page 19 in the January 1965 issue of *Radiological Health Data*, the contour line extending from Oregon through West Virginia and on to Texas is labeled "200". Subsequent inspection of the data shows that the line should have been labeled "50".

2. Colorado Milk Network, July–September 1964

Occupational and Radiological Health Division, Colorado State Department of Public Health

The Radiological Health Division of the Colorado State Department of Public Health initiated radiological analysis of milk in January 1962. The Denver Health Department collects weekly pasteurized milk composited samples from all major producers in the Denver area.

The State is divided into three major milk producing areas: west, northeast, and southeast. Routine sampling of raw milk began in August 1962. Raw milk shipped into Colorado from eastern Utah was also sampled. The four source areas are shown in figure 4. The frequency of sampling varies one to seventeen times per month in each active sampling area.

Samples are analyzed with the Division's low level counting facilities. The shield is an eight-food cube having five-inch steel walls lined with one-eighth inch of lead on the inside. A two-quart milk sample in a stainless steel container is analyzed with a 3 x 5-inch thallium-activated sodium iodide crystal and a 512-channel pulse height analyzer for forty minutes. The system is calibrated for routine calculation by the matrix method for the radionuclides iodine–131, barium–140, cesium–137, and potassium–40. The minimum detectable amount for the first three radionuclides at the 95 percent confidence level (± two standard deviations) is 20 pc/liter.

Table 5 gives the radionuclide concentration in milk samples collected from July through September 1964.

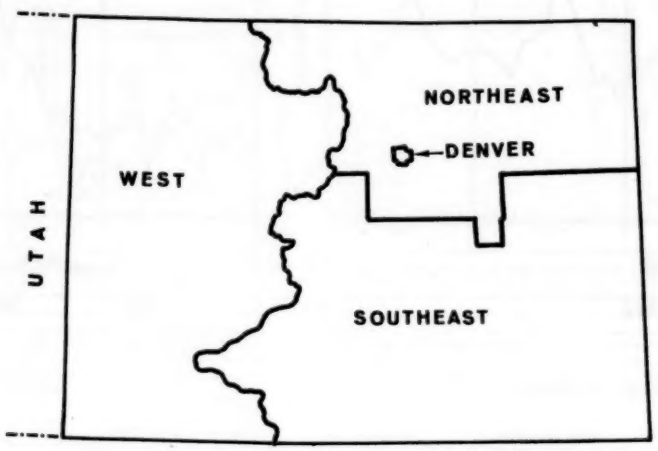

FIGURE 4.—COLORADO MILK SAMPLING AREAS

TABLE 5.—RADIONUCLIDES AND STABLE POTASSIUM IN COLORADO MILK, JULY-SEPTEMBER 1964[a]

[Radionuclide concentrations in pc/liter, potassium concentrations in g/liter]

Date (1964)	Raw milk												Pasteurized milk		
	Northeast			Southeast			West			Eastern Utah			Denver		
	K	I^{131}	Cs^{137}	K	I^{131}	Cs^{137}	K	I^{131}	Cs^{137}	K	I^{131}	Cs^{137}	K	I^{131}	Cs^{137}
July	1.45	<20	115	1.50	<20	75	[b] —	—	—	—	—	—	1.53	<20	123
August	1.44	<20	85	1.27	<20	68	1.15	<20	78	1.36	<20	121	1.54	<20	100
September	1.49	<20	76	1.51	<20	57	1.26	<20	20	1.32	<20	104	1.46	<20	77

[a] Barium-140 monthly averages were <20 pc/liter.
[b] Dash indicates no analysis.

3. Pennsylvania Milk Network, August–September 1964

Bureau of Environmental Health, Pennsylvania Department of Health

Samples of pasteurized milk are routinely collected from 10 major milk consumption areas throughout Pennsylvania (figure 5). Two samples per week are collected in Philadelphia and Pittsburgh, while weekly composite samples are collected from the other eight stations. At each sampling location subsamples are collected from the major dairies supplying the area and are composited in proportion to the amount of milk processed by each dairy. This composite is then sent to Radiation Laboratory of the Division of Occupational Health in Harrisburg where the weekly samples are combined for monthly analyses. Strontium–90 analyses have been carried out since April 1963.

The chemical separation technique for strontium–90 is essentially an ion exchange method described by Porter, *et al* (*3*). One liter of milk is passed through an ion exchange column; yttrium–90 is eluted from the resin and is counted in an automatic low background proportional counter.

The monthly average strontium–90 levels in pasteurized milk are shown in table 6.

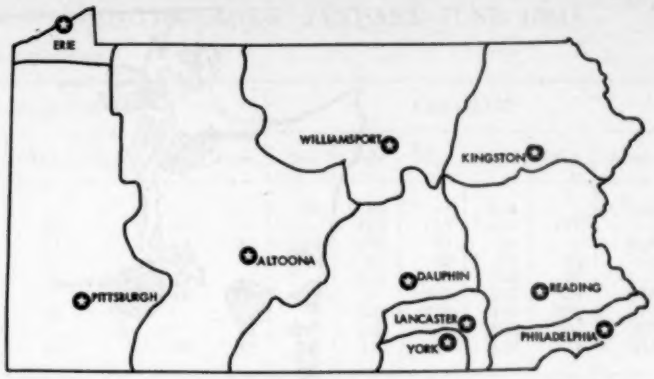

FIGURE 5.—PENNSYLVANIA MILK SAMPLING STATIONS AND MILK CONSUMPTION AREAS

TABLE 6. STRONTIUM-90 IN PENNSYLVANIA MILK, AUGUST–SEPTEMBER 1964

[Concentrations in pc/liter]

Sampling location	August	September
Altoona	35	30
Dauphin	25	21
Erie	28	25
Kingston	38	32
Lancaster	26	22
Philadelphia	28	24
Pittsburgh	31	30
Reading	20	19
Williamsport	34	27
York	20	20
State Average	28.5	25.0

Previous Coverage in *RHD* (Issue):

March 1964
July 1964
October 1964

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4. Washington Milk Network[3] January–June 1964

Air Sanitation and Radiation Control Section State of Washington Department of Health

The Washington State Department of Health initiated a surveillance program for radioactivity in raw milk in December 1962. The collection points shown in figure 6, were selected to provide samples representative of varying climatological conditions within the State's two major milksheds. As this sampling program also provides representation of a large percentage of the population's milk supply in the State, it would provide a basis for initiated countermeasures. In addition to sampling milk from eight locations in Washington, milk from Northwest Idaho (Sandpoint) is included in the network as this area forms a part of the Spokane milkshed. Several additional points are sampled from time to time.

Raw milk samples are collected routinely approximately every two weeks from individual tankers but the sampling frequency is flexible. Increased sampling can be initiated immediately if the need should arise.

[3] Data from *Environmental Radiation Surveillance in Washington State*, Third Annual Report, August 1964.

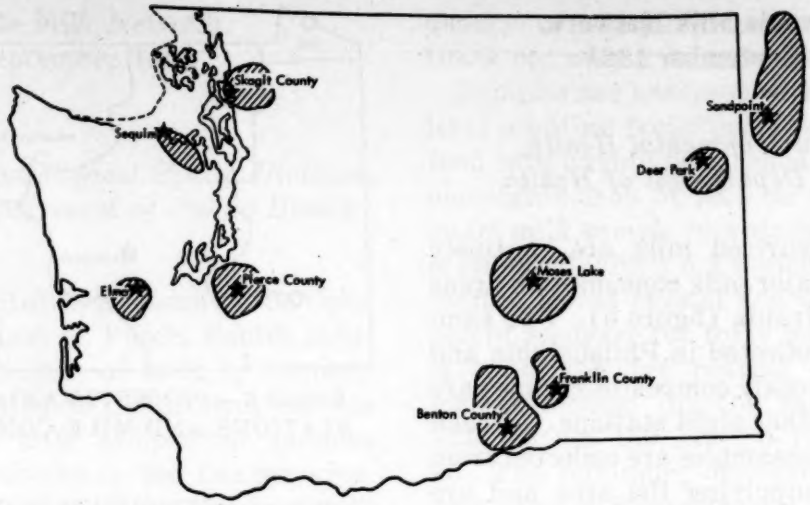

FIGURE 6.—WASHINGTON MILK SAMPLING LOCATIONS

Analytical Procedures

All milk samples are gamma scanned for 100 minutes in a 2-liter stainless steel Marinelli beaker. This beaker, which is placed in a 3″ x 3″ NaI (Tl) crystal, provides equal sample thickness on all sides and top of the crystal. The spectra are recorded with a 512-channel analyzer. A 4 x 4 matrix is used to analyze the spectra and provide rapid quantitative results for iodine–131, barium–140, cesium–137, and potassium–40.

An 800-minute background count is taken once each week. In order to check the stability of the analyzer, a one-minute count each day of a cesium–137 standard (solid) is done as an efficiency check, and a ten-minute count each week of the same source is done as a check on resolution. These counts must fall within two standard deviations of the average for the analyzer to be considered to be working normally. Gamma efficiencies, detectability limits and other characteristics of this system may be found in the "Washington Milk Network" article in the May 1964 issue of *RHD*.

Following gamma scanning, selected samples are analyzed for strontium–90. After the addition of strontium carrier, the milk proteins are precipitated with trichloracetic acid. Oxalic acid is then added to the sample to precipitate the alkaline earths as oxalates (pH 3.0). The oxalates are ashed, dissolved in 6 *N* hydrochloric acid, and the pH is adjusted to 1.4 to dissolve the ash. A double extraction using an equal volume of 20 percent di-(2–ethylhexyl) phosphoric acid (HDEHP) in toluene is performed. This effectively removes rare-earth activity, including yttrium–90, leaving the strontium–90 in the sample. This sample is stored a minimum of two weeks to allow yttrium–90 to ingrow. Subsequently, the yttrium–90 is extracted with 5 percent HDEHP in toluene solution. The organic layer is scrubbed with an HC1 solution (pH 1.4) and back extracted with 3N HNO_3. The resulting nitric acid solution is evaporated and yttrium–90 counted from which the strontium–90 activity is calculated. The yttrium–90 counting is done in a low-background, gas flow, internal proportional counter.

As a part of the laboratory's quality control program some samples are split and analyzed several times. Split samples are also exchanged with State, Federal and university laboratories for analyses and comparisons.

Results

Table 7 presents the monthly average radio nuclide content of raw milk for nine of the production areas in the major milksheds during the first six months of 1964. Iodine–131 and barium–140 have in general been nondetectable. For both cesium–137 and strontium–90 the Sandpoint production area had somewhat higher concentrations than the other areas during the period reported. Benton, Franklin, and Moses Lake have usually had the lower monthly averages.

TABLE 7.—RADIONUCLIDE CONCENTRATIONS IN WASHINGTON MILK, JANUARY–JUNE 1964 [a]

[Concentrations in pc/liter]

Location	Potassium-40						Strontium-90						Cesium-137					
	Jan	Feb	Mar	Apr	May	June	Jan	Feb	Mar	Apr	May	June	Jan	Feb	Mar	Apr	May	June
Benton Co.	1092	1269	—	1089	—	1236	14	13	—	[c]	—	[c]	70	88	—	122	—	98
Deer Park	[b] —	1236	1122	1184	1135	—	—	26	25	[c]	32	—	—	169	163	157	177	—
Elma	1225	1186	1197	—	—	1173	21	[c]	13	—	—	46	133	100	93	—	—	314
Franklin Co.	—	1217	1085	1156	1217	—	—	[c]	13	11	15	—	—	81	82	71	79	—
Moses Lake		1270	1192	1144	1207	—	—	[c]	10	16	13	—	—	110	93	92	77	—
Pierce Co.	1327	—	1215	1109	1227	1063	19	—	[c]	18	48	[c]	129	—	107	150	321	174
Sandpoint, Idaho	—	1277	1187	1167	1190	—	—	47	43	48	[c]	—	—	325	328	327	283	—
Sequim	1288	1290	1107	1297	1155	1180	18	17	[c]	18	[c]	23	140	122	188	122	97	232
Skagit Co.	1176	1196	1138	1095	1116	1023	24	[c]	16	[c]	29	48	121	113	113	119	158	211

[a] All I^{131} and Ba^{140} monthly averages during this period were <10 and <15 pc/liter respectively.
[b] Dash indicates no sample.
[c] No analysis.

5. Canadian Milk Network,[4] October 1964

Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium–90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963 liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and in addition it is possible to choose milk sampling locations (see figure 7) in the same areas as the air and precipitation stations. At present the analyses include determinations of iodine–131, strontium–89, cesium–137, and strontium–90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies and are combined into weekly composites and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine–131. The results of the spot checks for iodine–131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium–90, cesium–137, and stable potassium and calcium.

Analytical Methods

Radiochemical methods are used for the analysis of iodine–131 (4). For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet and evaporated under infra-red lamps. The residue is ashed in a muffle furnace at 450 degrees C., dissolved in dilute nitric acid, and strontium separated by fuming nitric acid precipitation. The combined strontium–89 and strontium–90 are determined by counting in a low background beta counter. Strontium–90 is determined separately by extracting and counting its yttrium–90 daughter, while strontium–89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium–137 is determined by gamma spectroscopy using a scintillation crystal and a multi-channel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium iodide crystal detector. The sample is

[4] Data from *Radiation Protection Programs*, Vol. 2, No. 11: 25–30, Radiation Protection Division, Canadian Department of National Health and Welfare (Nov. 1964).

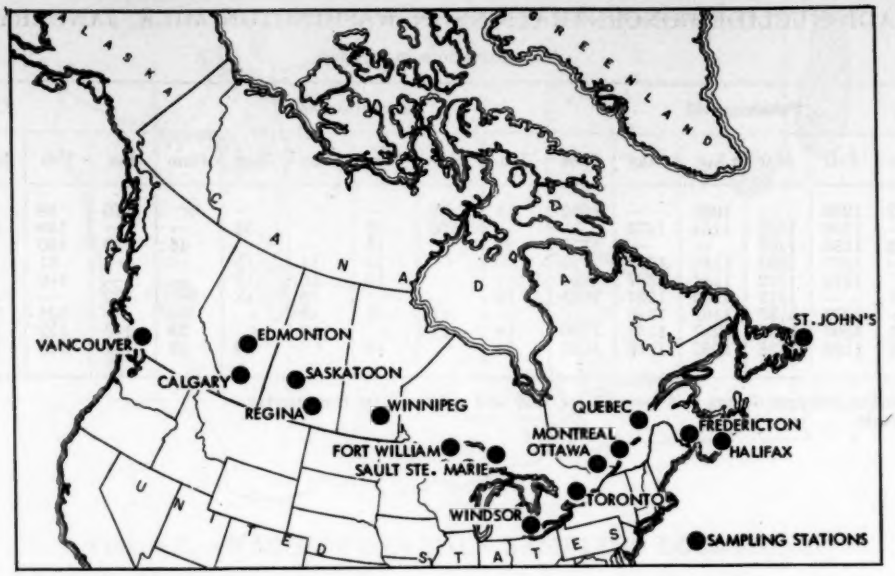

FIGURE 7.—CANADIAN MILK SAMPLING STATIONS

counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium–40 and cesium–137 content of the milk by comparison of the spectrum with the spectra of standard preparations of these two radionuclides. With this method the potassium–40 concentration is determined and the Compton contribution of this radionuclide to the cesium–137 photopeak is subtracted to obtain the cesium–137 concentration. The stable potassium content is estimated from the potassium–40 concentration.

Sources of Error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the carrier. In the determination of cesium–137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 8.

TABLE 8. TOTAL ERROR FOR VARIOUS RADIONUCLIDE CONCENTRATIONS IN MILK[a]

Nuclide	Error for 10 pc/liter	Error for 50 pc/liter	Error for 100 pc/liter
Strontium-89	±25%	±20%	±15%
Strontium-90	±15%	±10%	±10%
Iodine-131	±50%	±20%	±10%
Cesium-137	±60%	±20%	±10%

[a] All errors are 2σ values, representing 95 percent confidence levels.

Results

Table 9 presents monthly averages of strontium–90, cesium–137, and stable calcium and potassium in Canadian whole milk. Spot checks for iodine–131 and strontium–89 indicate that all samples had <5 pc/liter.

TABLE 9. RADIONUCLIDES IN CANADIAN WHOLE MILK, OCTOBER 1964

[Radionuclide concentrations in pc/liter]

Station	Calcium (g/liter)	Potassium (g/liter)	Iodine-131 (pc/liter)	Strontium-90 (pc/liter)	Cesium-137 (pc/liter)
Calgary	1.10	1.5	16	27.3	124
Edmonton	1.17	1.6	17	26.2	104
Ft. William	1.10	1.6	19	49.7	202
Fredericton	1.21	1.5	2	39.8	169
Halifax	1.17	1.6	5	41.0	187
Montreal	1.10	1.7	11	24.5	103
Ottawa	1.17	1.6	5	23.3	94
Quebec	1.15	1.7	11	39.6	159
Regina	1.13	1.6	4	33.4	105
St. John's, Nfld	1.13	1.6	8	53.5	209
Saskatoon	1.17	1.6	10	31.5	93
Sault Ste. Marie	1.10	1.6	10	44.9	173
Toronto	1.15	1.6	19	14.2	69
Vancouver	1.21	1.6	3	48.1	271
Windsor	1.15	1.5	23	11.8	57
Winnipeg	1.13	1.7	28	30.9	139
Average	1.15	1.6	12	33.7	141

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APPLICATION OF RADIONUCLIDE CONCENTRATIONS IN MILK TO DOSE ASSESSMENT, NOVEMBER 1963–OCTOBER 1964

Division of Radiological Health, Public Health Service

The concentrations of specific radionuclides in milk analyzed as part of the Pasteurized Milk Network (PMN) is reported on a monthly basis in *RHD*. In terms of radiological health surveillance activity, an important aspect of these data is the estimation of resultant radiation dose to population groups.

Approximate relationships between certain radionuclide intakes and dose have been applied to the formulation of daily intake guides (*1*) and permissible concentrations in selected environmental media (*2*). Although these guides are not themselves directly applicable to worldwide fallout, a comparison with environmental contamination levels does yield a measure of population dosage. In general, intake-dose and dose-biological effect relationships used in formulating the guides cited are based on continuous intake over an entire lifetime. However, for general surveillance purposes, yearly average intakes, used with discretion, may be compared directly with the levels adopted as lifetime intake guides. Thus, the radionuclide concentrations in milk, averaged over a year's time, together with milk consumption data, might be used in conjunction with the references cited above to approximate the radiation dose to a specific population group from a specific radionuclide. Table 1 presents annual averages of radionuclide concentrations in milk sampled by the *PMN*. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U. S. population (*3, 4*).

Total dietary intake is of prime interest, and since the intake via milk consumption constitutes only a portion of the total radionuclide intake, the relationship of milk intake to total dietary intake is of importance in evaluating milk surveillance data. The Federal Radiation Council (*5*) notes: "A number of studies have shown that conservative estimates of the strontium–90 to calcium ratio in the total diet may be made by multiplying the ratio of strontium–90 to calcium in milk in a particular locality by 1.5." [1] Thus, a rough index of the total dietary intake of strontium–90 on an annual basis may be made from PMN annual averages by using this factor and the assumptions of approximately 1.2 g of calcium per liter in PMN samples and a 1.0 g daily intake of calcium.

In the case of iodine–131, milk can be considered the major source because of the rapid distribution and consumption of fresh milk. With most other foods, normal processing and distribution allow time for the radioactive decay of this short-lived nuclide to insignificant levels.

The situation with respect to strontium–89 is more complicated. Its physical half-life of some 50 days makes it difficult to estimate the relative contribution made by sources other than milk to the total dietary intake.

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[1] This ratio may vary from 1 to 2, depending on changes in rate of fallout deposition and relative consumption of non-milk products whose contamination reflect temporal and local deposition patterns (6).

TABLE 1.—MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK,[a] NOVEMBER 1963–OCTOBER 1964

[Concentrations in pc/liter]

Sampling locations		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		Oct 1963–Sept 1964 [a]	Nov 1963–Oct 1964 [b]	Oct 1963–Sept 1964 [a]	Nov 1963–Oct 1964 [b]	Oct 1963–Sept 1964 [a]	Nov 1963–Oct 1964 [b]	Oct 1963–Sept 1964 [a]	Nov 1963–Oct 1964 [b]
Ala:	Montgomery	3	3	23	23	0	0	86	84
Alaska:	Palmer	9	6	24	23	0	0	149	141
Ariz:	Phoenix	3	3	4	4	0	0	26	25
Ark:	Little Rock	5	4	45	45	0	0	134	129
Calif:	Sacramento	3	3	9	8	0	0	51	48
	San Francisco	4	4	10	10	0	0	58	54
C. Z:	Cristobal	3	3	5	5	0	0	48	50
Colo:	Denver	6	4	19	19	0	0	92	91
Conn:	Hartford	4	3	22	22	0	0	156	148
Del:	Wilmington	3	3	24	23	0	0	128	123
D. C:	Washington	4	3	19	19	0	0	88	86
Fla:	Tampa	3	3	16	16	0	0	241	236
Ga:	Atlanta	5	4	32	31	0	0	139	136
Hawaii:	Honolulu	4	3	11	11	0	0	80	78
Idaho:	Idaho Falls	13	11	28	27	0	0	177	168
Ill:	Chicago	4	3	20	19	0	0	118	115
Ind:	Indianapolis	4	3	22	21	0	0	100	98
Iowa:	Des Moines	8	6	26	25	0	0	95	91
Kans:	Wichita	6	5	21	21	0	0	68	66
Ky:	Louisville	6	4	32	31	0	0	94	91
La:	New Orleans	5	4	51	51	0	0	149	144
Maine:	Portland	5	3	32	31	0	0	210	201
Md:	Baltimore	5	3	22	22	0	0	103	99
Mass:	Boston	5	3	34	33	0	0	235	223
Mich:	Detroit	3	3	19	19	0	1	117	113
	Grand Rapids	4	3	21	21	0	0	127	124
Minn:	Minneapolis	11	9	33	33	0	0	154	147
Miss:	Jackson	6	5	42	41	0	0	110	107
Mo:	Kansas City	8	7	29	28	0	0	85	81
	St. Louis	7	5	23	23	0	0	85	82
Mont:	Helena	7	6	28	26	0	1	184	175
Nebr:	Omaha	9	6	27	26	0	0	99	95
Nev:	Las Vegas	6	5	10	10	0	1	78	73
N. H:	Manchester	5	3	33	32	0	0	247	236
N. J:	Trenton	4	3	19	19	0	0	118	114
N. Mex:	Albuquerque	3	3	11	11	0	1	55	54
N. Y:	Buffalo	4	3	21	20	0	0	146	141
	New York	5	4	27	26	0	0	166	159
	Syracuse	[c] 4	[d] 3	[c] 21	[d] 20	[c] 0	[d] 0	[c] 145	[d] 139
N. C:	Charlotte	5	4	36	36	0	0	115	112
N. Dak:	Minot	9	3	58	57	0	0	156	152
Ohio:	Cincinnati	4	3	24	23	0	0	94	92
	Cleveland	3	3	22	21	0	0	115	113
Okla:	Oklahoma City	4	3	23	23	0	0	72	70
Ore:	Portland	10	8	32	31	0	0	172	164
Pa:	Philadelphia	3	3	21	20	0	0	123	119
	Pittsburgh	4	3	30	29	0	0	153	148
P. R:	San Juan	3	3	13	12	0	0	74	73
R. I:	Providence	3	3	25	25	0	0	170	163
S. C:	Charleston	5	3	32	32	0	0	130	127
S. Dak:	Rapid City	11	8	43	43	0	0	156	152
Tenn:	Chattanooga	6	5	41	41	0	0	125	120
	Memphis	5	3	32	32	0	0	76	74
Tex:	Austin	3	3	9	9	0	0	42	41
	Dallas	3	3	20	20	0	0	69	66
Utah:	Salt Lake City	9	8	27	27	0	0	185	178
Vt:	Burlington	5	3	27	26	0	1	187	178
Va:	Norfolk	4	3	18	18	0	0	96	94
Wash:	Seattle	9	7	28	26	0	0	159	152
	Spokane	10	8	30	29	0	0	148	142
W. Va:	Charleston	5	4	28	27	0	0	85	81
Wis:	Milwaukee	3	3	18	18	0	0	133	130
Wyo:	Laramie	10	8	22	21	0	0	112	107
Network average		5	4	25.0	24.5	0	<10	122	118

[a] Averages computed for 52 weeks.
[b] Averages computed for 53 weeks.
[c] Averages computed for 48 weeks. No samples were collected during July 1964.
[d] Averages computed for 49 weeks. No samples were collected during July 1964.

The relative contribution of milk to the total dietary intake of cesium–137 is not well defined and depends principally on the amount of freshly deposited cesium–137 on products used for human and animal consumption, and the progress of cesium–137 through the food chain.

The data in table 1 are calculated as follows: results from all samples collected in each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of twelve consecutive months are averaged to obtain the annual average.[2] To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk.

Monthly variations of radionuclides concentrations in milk are influenced by a number of combined causes such as meteorologic conditions and dairying practices, apart from considerations of original sources of radionuclides. The moving yearly average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations. This method, therefore, shows trends over a considerable period of time.

[2] Iodine–131 values of <10 pc/liter are considered to be zero for averaging purposes; previously, 5 pc/liter was used for calculating the averages.

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Section III—Water

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, AUGUST 1964

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been monitored by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this system has expanded to 131 stations as of January 1, 1965. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U. S. river basins for physical, chemical, biological, and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the system provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be exposed. Data assembled through the system and exact locations of sampling points are published in annual compilation (*1–7*).

Sampling Procedures

The participating agencies collect one-liter "grab" samples each week and ship them "as is" to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids are performed as frequently as deemed necessary.

Presently, gross alpha and beta determinations are made on either monthly composites of the weekly samples or on each weekly sample. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radioactive waste. Weekly analyses are also conducted at newly established stations for the first year of operation.

Normally, samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the time of collection.

Strontium–90 analyses are performed on total solids of three-month composites of the weekly samples. The most recent strontium–90 results are presented in the December 1964 issue of *RHD*.

Analytical Methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*8*). Suspended and dissolved solids are separated by passing the sample through a mem-

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brane filter (type HA) with a pore size of 0.45 micron. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is in proper calibration, are used for daily checking of the counter.

Results

Table 1 presents August 1964 results of alpha and beta analyses of U.S. surface waters. The stations on a river are arranged in the table according to their relative location on the river, the first stations listed being closest to the headwaters. These data are preliminary. Replicate analyses of some samples as well as some analyses incomplete at the time of this report will be included in the system's "Annual Compilation of Data" (*7*). The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pc/liter. When all samples have zero pc/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5 the mean is reported as <1 pc/liter.

A geographical perspective of the radioactivity in surface water is obtained from the numbers printed near the stations shown in figure 1, which gives the August 1964 average

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, AUGUST 1964

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	19	12	31	4	1	5
Arkansas River:						
Coolidge, Kansas	9	47	56	1	9	10
Ponca City, Okla.	53	40	93	7	2	9
Atchafalaya River:						
Morgan City, La.	9	22	31	2	2	4
Bear River:						
Preston, Idaho	1	25	26	0	2	2
Big Horn River:						
Hardin, Mont.	159	32	191	61	7	68
Chena River:						
Fairbanks, Alaska	5	6	11	0	0	0
Clinch River:						
Clinton, Tenn.	3	5	8	0	0	0
Kingston, Tenn.	28	58	86	1	2	3
Colorado River:						
Loma, Colo.	225	38	263	53	6	59
Page, Ariz.	2	32	34	0	5	5
Parker Dam, Calif-Ariz.	3	17	20	0	6	6
Columbia River:						
Wenatchee, Wash.	5	14	19	0	0	0
Pasco, Wash.	41	279	320	0	0	0
Clatskanie, Ore.	19	94	113	0	0	0
Connecticut River:						
Enfield Dam, Conn.	2	6	8	0	0	0
Coosa River:						
Rome, Ga.	4	8	12	0	0	0
Cumberland River:						
Cheatham Lock, Tenn.	0	8	8	0	0	0
Delaware River:						
Philadelphia, Pa.	5	11	16	0	0	0
Great Lakes:						
Duluth, Minn.	2	4	6	0	0	0
Hudson River:						
Poughkeepsie, N.Y.	8	22	30	0	1	1
Illinois River:						
Grafton, Ill.	7	19	26	1	3	4
Kansas River:						
De Soto, Kans.	17	34	51	3	1	4
Maumee River:						
Toledo, Ohio	5	23	28	1	0	1
Mississippi River:						
St. Paul, Minn.	4	34	38	1	1	2
E. St. Louis, Ill.	6	25	31	1	3	4
New Roads, La.	1	15	16	0	1	1
New Orleans, La.	5	23	28	0	1	1
Missouri River:						
Williston, N. Dak.	1	16	17	1	3	4
St. Joseph, Mo.	16	29	45	8	7	15
North Platte River:						
Henry, Nebr.	8	79	87	1	14	15
Ohio River:						
Cairo, Ill.	0	16	16	0	0	0
Toronto, Ohio	5	19	24	0	0	0
Platte River:						
Plattsmouth, Nebr.	43	34	77	6	2	8
Potomac River:						
Washington, D.C.	2	7	9	0	1	1
Red River, North:						
Grand Forks, N. Dak.	1	55	56	0	4	4
Red River, South:						
Alexandria, La.	2	27	29	1	0	1
Rio Grande River:						
El Paso, Tex.	1	31	32	0	1	1
Laredo, Tex.	59	25	84	6	1	7
San Joaquin River:						
Vernalis, Calif.	17	17	34	1	9	10
San Juan River:						
Shiprock, N. Mex.	971	39	1010	229	2	231
Savannah River:						
Port Wentworth, Ga.	9	20	29	<1	<1	<1
Snake River:						
Wawawai, Wash.	1	5	6	0	2	2
South Platte River:						
Julesburg, Colo.	2	52	54	0	16	16
Susquehanna River:						
Conowingo, Md.	7	15	22	0	0	0
Tennessee River:						
Chattanooga, Tenn.	0	6	6	1	0	1
Wabash River:						
New Harmony, Ind.	4	12	16	0	1	1
Yellowstone River:						
Sidney, Mont.	39	20	59	12	3	15
Maximum	971	279	1010	229	16	231
Minimum	0	4	6	0	0	0

Note: These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the system's annual report.

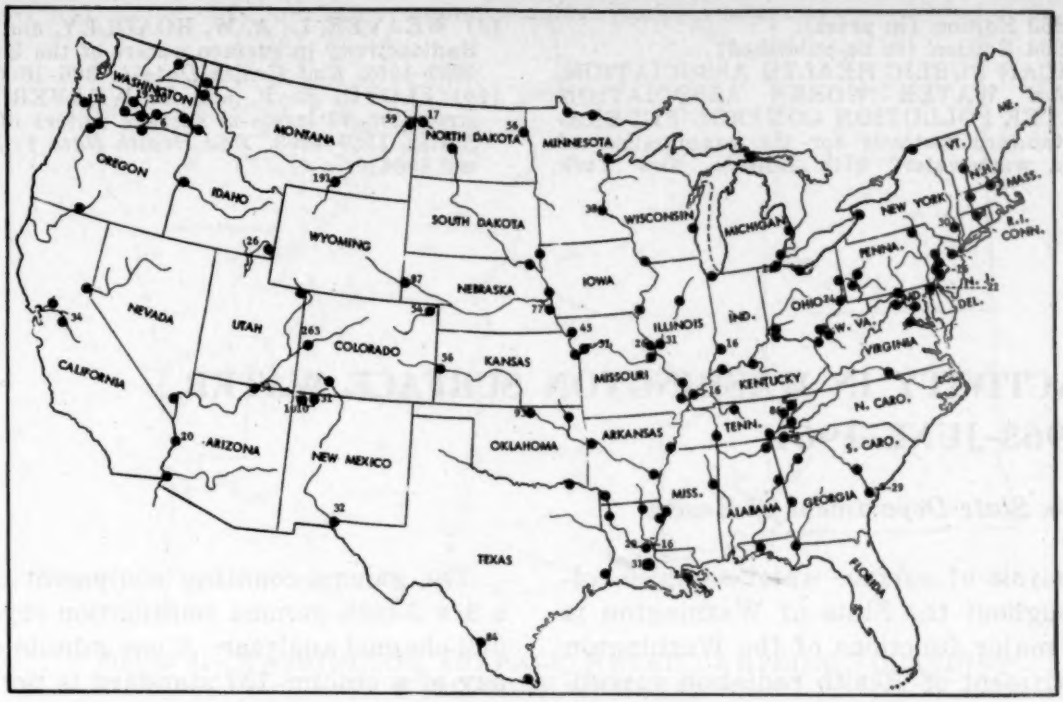

FIGURE 1.—SAMPLING LOCATIONS AND ASSOCIATED TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATERS, AUGUST 1964

total beta activity in suspended-plus-dissolved solids in raw water collected at each station. Gross radioactivity results for the years 1957–1962 have been summarized by Weaver *et al* (*9*). Floyd and Weaver summarized the strontium–90 results obtained from 1959 through 1963 in the August 1964 issue of *RHD* (*10*).

Discussion

The monthly dissolved beta activity averages exceeded 100 pc/liter at only one station, the Pasco, Washington station on the Columbia River.

Dissolved alpha activity, associated with the dissolving of natural surface minerals by water, ranged from 0 to 16 pc/liter. Two stations on different rivers had monthly average dissolved alpha activity greater than 10 pc/liter.

Analysis of the preliminary August 1964 data indicates elevated levels of alpha and beta activity (pc/liter) in the suspended solids fraction. The monthly average suspended alpha and beta activities in the San Juan River at Shiprock, New Mexico were 229 and 971 pc/liter, respectively. The dissolved alpha and beta activities were not significantly different from those commonly observed at this sampling station. The samples associated with these unusually high averages contained large quantities of suspended solids. Thus, only quite small aliquots could be used in the laboratory determinations to avoid excessive beta self-absorption. In such cases the relatively large multiplication factor, together with the usual range of counting errors associated with standard counting periods, can result in apparently abnormal levels of radioactivity. The specific activity (pc/g) of the samples discussed above was determined and found to be comparable to specific activity observed normally in samples from this station. The apparent increased activity, therefore, may be attributed to the extremely high suspended solids content of the sample and considered essentially of natural origin.

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(*2*) *Ibid.*, 1959 Edition. Price $1.75.
(*3*) *Ibid.*, 1960 Edition.[1]
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RADIOACTIVITY IN WASHINGTON SURFACE WATER,[1] JULY 1963–JUNE 1964

Washington State Department of Health

Radioanalysis of surface water samples collected throughout the State of Washington is one of the major functions of the Washington State Department of Health radiation surveillance program. Most surface water samples are collected quarterly from 70 stations located on 59 rivers throughout the State. These samples are collected by the Washington Pollution Control Commission and are sent to the Department of Health for radiological analyses. A few locations are sampled less frequently, and selected stations on the Columbia River are sampled weekly by local health department sanitarians. All surface water samples are collected as grab samples in a 2-liter plastic bottle. Two milliliters of concentrated nitric acid are added to the sample before shipment to the laboratory to prevent loss of activity to the container.

Analytical Procedures

Surface water samples are placed in stainless steel Marinelli beakers for the gamma analyses. Distilled water is added when necessary to obtain 2-liter volumes for standardizing counting geometry. These samples are gamma scanned for 100 minutes approximately two weeks after collection. This two-week period permits the decay of short-lived isotopes (Na^{24}, As^{76}, Np^{239}) in Columbia River water samples. The matrix method, utilizing a 4 x 4 matrix, permits the estimation of Cr^{51}, Ru^{106}, Zr^{95}, and Zn^{65}. Results are extrapolated to the date of collection.

The gamma-counting equipment consists of a 3 x 3-inch gamma scintillation crystal and a 512-channel analyzer. A one-minute count each day of a cesium–137 standard is performed as an efficiency check, and a ten-minute count each week is done to check the resolution. An 800-minute count each week is taken to check the background. Table 1 gives the gamma efficiencies and detectability limits for this system.

After the gamma scan, the water samples receive further preparation and are beta counted approximately eighteen days after sample collection for suspended and soluble radioactivity. The separation of dissolved and suspended activity is accomplished by filtering the acidified sample (Wattman #42 filter paper). The filtrate, evaporated to near dryness, is quantitatively transferred to a tared planchet and dried for gross beta counting. The filter paper containing the suspended matter is ashed in a muffle furnace at 600° C and transferred to a planchet for gross beta counting.

TABLE 1. BETA AND GAMMA EFFICIENCIES AND DETECTABILITY LIMITS FOR THE WASHINGTON STATE ANALYSES

Radionuclide	Energy band (Mev)	Efficiency (%)	Average background (pc)	Detectability limits (pc)
Beta				
Sr^{90}–Y^{90}	—	33	0.68	0.27
Y^{90}	—	37	0.61	0.24
P^{32}	—	31	0.73	0.29
Gamma				
Cs^{137}	0.62–0.72	2.50	230	30
Cr^{51}	0.30–0.36	0.45	2,600	220
Ru^{106}	0.44–0.56	0.94	1,200	100
Zr^{95}	0.73–0.79	6.00	51	10
Zn^{65}	1.05–1.17	0.94	340	50

[1] Summarized from *Environmental Radiation Surveillance in Washington State,* (1).

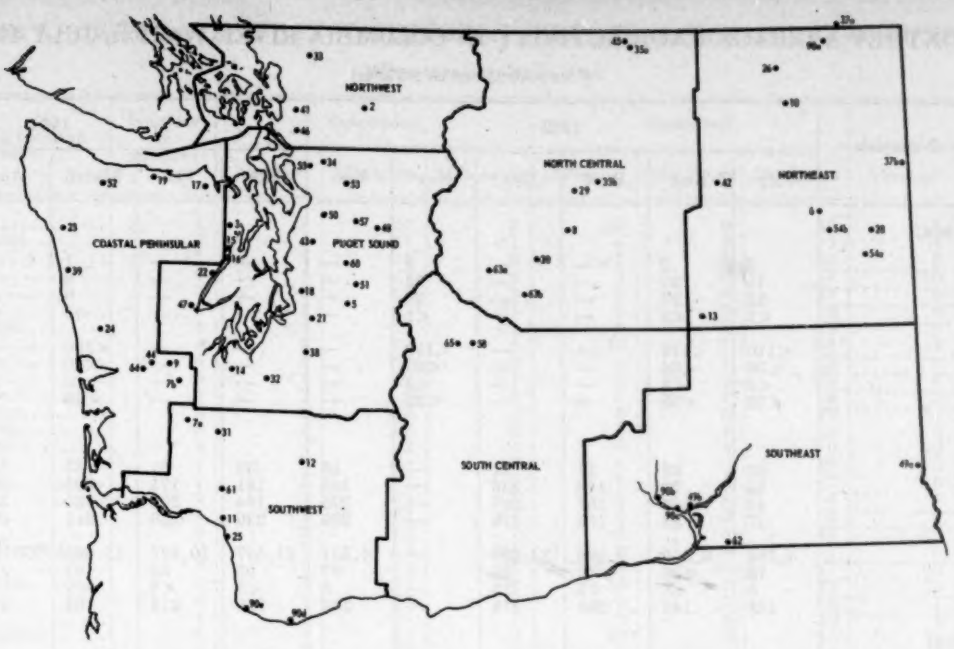

FIGURE 1.—WASHINGTON SURFACE WATER SAMPLING LOCATIONS WITH CODE NUMBERS

Counting time is 100 minutes. After obtaining the net beta counting rate, corrections for self absorption are made and the results converted to concentrations in water. Gross beta results are not extrapolated to date of collection.

In addition to the above analyses, water samples from the Columbia River are also analyzed for P^{32}. The technique used for P^{32} separation is a modification of published methods (2, 3, 4, 5). After the sample has been stored for fifteen days, which allows As^{96} and other short-lived interfering radionuclides to decay, the phosphorus is separated by precipitation as ammonium phosphomolybdate from a dilute acid medium. The precipitate is washed with ammonium nitrate, transferred into a tared planchet, ashed, weighed, and counted for beta activity. The counting rate is corrected for self absorption, P^{32} efficiency, and the decay rate. The results are converted to concentrations in water.

Beta counting is done with a low background beta system including a 2-inch detector and automatic sample changer. This system has an average background of 0.5 counts per minute. Background counts are performed as an integral part of each sample. Gross beta calibration of the instrument is done with a Sr^{90}–Y^{90} standard.

Results

Table 2 presents the monthly average results for the Columbia River Stations which are sampled routinely. In averaging, a less-than value is assumed to be equal to one half the numerical value.

Table 3 summarizes the beta activity measurements from the 65 other surface water stations from July 1963 through June 1964. The first column in this table gives code numbers and the abbreviations denoting geographical sections (in figure 1). Each river is assigned a number and if more than one station is located on that river, lower case letters are used to designate these stations. For example, code number 21 refers to the Green River sampling station in the area designated "PS", i.e. Puget Sound. The third column gives the total number of samples analyzed.

Gamma scans of the samples in table 3 indicated no detectable activity except in four samples. Among there four samples, Ru^{106} concentrations ranged to 107 pc/liter, and Zr^{95} concentrations ranged to 11 pc/liter.

The network summary gives the maximum and minmum values for the 224 samples analyzed, while the network average is obtained by averaging all the station average values.

TABLE 2.—MONTHLY AVERAGE RADIOACTIVITY IN COLUMBIA RIVER WATER, JULY 1963–JUNE 1964

[Concentrations in pc/liter]

Location and type of anaylsis	1963						1964					
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	Apr	May	June
Northport (Code No. 90a)												
Beta												
Suspended [a]	2	2	[b] —	—	2	—	—	—	1	—	—	1
Dissolved [a]	19	21	—	—	26	—	—	—	8	—	—	10
Total [a]	21	23	—	—	28	—	—	—	9	—	—	11
Phosphorus-32 [c]	<1	<1	—	—	<1	—	—	—	<1	—	—	<1
Gamma [c]												
Chromium-51	<110	<110	—	—	<110	—	—	—	<110	—	—	<110
Ruthenium-106 [d]	<50	<50	—	—	<50	—	—	—	<50	—	—	<50
Zirconium-95	<5	<5	—	—	<5	—	—	—	<5	—	—	<5
Zinc-65	<25	<25	—	—	<25	—	—	—	<25	—	—	<25
Pasco (Code No. 90c)												
Beta												
Suspended [a]	10	32	51	21	—	16	33	31	37	52	14	16
Dissolved [a]	34	70	146	236	—	195	161	171	203	282	56	43
Total [a]	44	102	197	257	—	225	194	202	233	334	70	59
Phosphorus-32 [c]	27	86	166	476	—	289	230	236	211	366	53	59
Gamma [c]												
Chromium-51	4,798	8,309	7,028	23,899	—	14,831	11,597	10,927	13,020	17,293	2,251	1,603
Ruthenium-106 [d]	78	<50	70	82	—	67	95	53	93	132	<50	<50
Zirconium-95	6	<5	<5	<5	—	6	<5	<5	<5	7	<5	<5
Zinc-65	138	140	235	278	—	243	296	218	192	240	149	92
Richland (Code No. 90b)												
Beta												
Suspended [a]	—	—	—	—	—	—	—	—	—	117	130	19
Dissolved [a]	—	—	—	—	—	—	—	—	—	334	271	80
Total [a]	—	—	—	—	—	—	—	—	—	451	401	99
Phosphorus-32 [c]	—	—	—	—	—	—	—	—	—	522	369	114
Gamma [c]												
Chromium-51	—	—	—	—	—	—	—	—	—	11,713	6,471	2,794
Ruthenium-106 [d]	—	—	—	—	—	—	—	—	—	222	133	<100
Zirconium-95	—	—	—	—	—	—	—	—	—	<10	18	<10
Zinc-65	—	—	—	—	—	—	—	—	—	580	599	158
Vancouver (Code No. 90e)												
Beta												
Suspended [a]	14	12	7	8	11	10	12	9	18	19	26	15
Dissolved [a]	28	28	31	41	44	62	52	57	60	56	54	32
Total [a]	42	40	38	49	55	72	64	66	78	75	80	47
Phosphorus-32 [c]	24	24	15	28	43	76	61	80	63	76	81	41
Gamma												
Chromium-51	1,686	3,712	3,913	4,455	4,479	4,901	3,842	4,037	3,890	2,834	2,228	1,192
Ruthenium-106 [d]	<50	<50	<50	109	<50	<50	<50	<50	<50	<50	<50	<50
Zirconium-95	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Zinc-65	58	40	<25	35	<25	49	49	55	59	62	93	66
Washougal (Code No. 90d)												
Beta												
Suspended [a]	15	12	7	9	11	10	17	11	16	19	24	13
Dissolved [a]	28	28	31	42	48	62	56	66	54	64	55	33
Total [a]	43	40	38	51	59	72	73	77	70	83	79	46
Phosphorus-32 [c]	23	22	14	28	49	78	69	83	59	79	82	39
Gamma [c]												
Chromium-51	1,893	3,782	3,859	4,671	5,355	5,272	4,532	4,484	4,284	3,038	2,280	1,345
Ruthenium-106 [d]	<50	<50	<50	87	<50	<50	<50	<50	<50	<50	<50	<55
Zirconium-95	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Zinc-65	60	31	<25	35	<25	43	53	69	49	62	98	59

[a] Activity at time of counting. Sr^{90}–Y^{90} calibration standard in suspended and dissolved solids acidified.
[b] Dash indicates no sample.
[c] Results extrapolated to date of collection.
[d] Net activity in the 0.44–0.56 mev gamma range is assumed to be only Ru^{106}.

Discussion

Of the 224 river water samples analyzed from July 1963 through June 1964 (excluding the Columbia River), the total beta activity ranged from 1 to 89 pc/litter with an average of 11.8 pc/liter. The activity of the soluble fraction was somewhat lower, ranging from 1 to 59 pc/liter and averaging 9.5 pc/liter. These network averages during the June 1963 through July 1964 period were lower by about a factor of two than the averages for the preceding twelve months.

Monthly average total beta activity for the Columbia River stations below the Hanford Facility ranged from 38 to 451 pc/liter. Monthly average concentrations of the beta-emitter, P^{32}, in the Columbia river water samples taken below the Hanford Facility ranged from 14 to 522 pc/liter.

The radionuclides Ru^{106} and Zr^{95} were found in monthly average concentrations that ranged from <50 to 222 pc/liter for Ru^{106}, and <5 to 18 pc/liter for Zr^{95}. The values for Ru^{106} are probably a combination of Ru^{103} and Ru^{106}. The

TABLE 3.—BETA ACTIVITY IN WASHINGTON SURFACE WATER, JULY 1963–JUNE 1964

[Concentrations in pc/liter]

Code number and area	Sampling location (river)	Number of samples	Suspended			Dissolved			Total		
			Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum
2 NW	Baker	4	2	<1	3	13	9	15	15	9	17
3 PS	Big Quiliene	2	<1	<1	<1	4	2	5	4	2	5
5 PS	Cedar	12	2	<1	9	7	2	26	9	3	35
7a SW	Chehalis	4	1	<1	4	9	6	14	10	6	18
7b CP	Chehalis	3	1	<1	2	8	6	11	9	8	12
8 NC	Chelan	4	<1	<1	<1	6	5	8	6	5	8
9 CP	Cloquallam	4	<1	<1	<1	6	4	8	6	4	8
10 NE	Colville	4	2	<1	3	10	7	16	12	7	18
11 SW	Coweman	4	1	<1	3	6	3	10	7	3	11
12 SW	Cowlitz	3	<1	<1	<1	5	4	9	6	4	9
14 PS	Deschutes	3	2	2	2	7	5	8	9	7	10
15 PS	Dosewallips	2	3	<1	5	8	5	10	10	5	15
16 PS	Duckabush	2	1	<1	2	7	4	9	8	4	11
17 CP	Dungeness	2	3	2	4	7	4	9	10	6	13
18 PS	Duwamish	4	3	<1	6	9	4	13	12	4	16
19 CP	Elwha	2	2	1	3	6	5	7	8	6	10
20 NC	Entiat	4	1	<1	2	6	4	8	7	4	10
66 PS	Ft. Lewis	2	<1	<1	<1	3	2	3	3	2	3
21 PS	Green	4	2	<1	4	8	3	14	10	3	17
22 PS	Hamma Hamma	2	<1	<1	<1	3	2	4	3	2	4
23 CP	Hoh	2	17	2	32	23	14	31	40	16	63
24 CP	Humptulips	4	3	<1	11	10	3	16	13	3	27
25 SW	Kalama	4	1	<1	2	6	3	8	7	3	9
26 NE	Kettle	4	<1	<1	1	8	6	10	9	6	11
28 NE	Little Spokane	4	1	<1	2	10	8	13	11	8	15
29 NC	Methow	4	1	<1	2	5	4	8	6	4	10
31 SW	Newaukum	4	1	<1	3	7	5	8	8	6	11
32 PS	Nisqually	4	1	<1	2	11	10	13	12	10	14
33 NW	Nooksak	4	10	<1	20	16	5	29	26	5	49
34 PS	N. Stillaguamish	3	1	<1	3	8	6	10	10	6	13
35a NC	Okanogan	2	2	1	2	15	14	15	16	15	17
35b NC	Okanogan	4	1	<1	4	11	8	15	12	8	19
37a NE	Pend Oreille	4	1	<1	3	10	8	12	12	9	13
37b NE	Pend Oreille	5	<1	<1	1	10	8	15	10	8	15
38 PS	Puyallup	4	10	<1	30	24	3	59	33	3	89
39 CP	Queets	2	16	2	29	17	12	21	32	14	50
67 CP	Quinault	2	1	<1	2	9	7	11	10	7	13
41 NW	Samish	4	3	<1	6	9	6	15	12	6	21
42 NE	Sanpoil	4	<1	<1	<1	6	4	9	6	4	9
43 PS	Sammamish	4	4	3	4	14	8	19	18	11	23
44 CP	Satsop	4	4	<1	14	8	3	12	13	3	26
45 NC	Similkameen	2	1	<1	2	10	5	14	11	5	16
46 NW	Skagit	4	12	1	39	19	7	43	31	8	82
47 PS	Skokomish	2	2	<1	4	5	1	9	7	1	13
48 PS	Skykomish	4	1	<1	3	11	5	17	13	5	19
49a SE	Snake	4	1	<1	1	11	9	14	12	9	15
49b SE	Snake	2	3	2	4	13	12	14	16	14	18
50 PS	Snohomish	4	1	<1	3	11	7	19	12	7	22
51 PS	Snoqualimie	4	2	<1	6	11	7	15	13	7	19
52 CP	Soleduck	2	3	<1	5	9	4	13	11	4	18
53 PS	S. Stillaguamish	4	3	1	5	11	6	14	13	7	19
54a NE	Spokane	4	1	<1	2	10	7	11	10	7	13
54b NE	Spokane	4	<1	<1	1	8	7	10	8	7	10
55 PS	Stillaguamish	3	2	1	2	8	6	9	9	7	11
56 PS	Stuck	3	1	<1	2	15	10	24	17	10	26
57 PS	Sultan	4	2	<1	3	9	6	10	10	6	13
58 SC	Teanaway	2	2	<1	4	5	3	7	7	3	11
60 PS	Tolt	4	2	<1	3	10	8	13	11	8	16
61 SW	Toutle	4	1	<1	3	8	4	11	10	4	14
62 SE	Walla Walla	2	4	3	4	13	9	16	16	13	19
63a NC	Wenatchee	3	<1	<1	<1	10	9	11	10	9	11
63b NC	Wenatchee	4	1	<1	3	10	8	14	11	8	15
64 CP	Wynoochee	4	4	<1	14	8	3	16	12	3	30
65 SC	Yakima	3	<1	<1	2	10	5	9	11	5	11
Network summary		224	2.5	<1	39	9.5	1	59	11.8	1	89

radionuclides Ru^{106} and Zr^{95} were found in four samples from other river basins as well as in the Columbia River. Two other radionuclides, Cr^{51} and Zn^{65}, were found in detectable quantities only in Columbia River water. Monthly averages for Cr^{51} ranged from 1,192 to 23,899 pc/liter, and for Zn^{65} the range was <25 to 599 pc/liter.

Although any standards for gross beta activity must be very carefully applied, the standard for drinking water is 1,000 pc/liter of beta activity in the absence of strontium-90 and alpha emitters (*6*). The standards for water from all dietary sources for the general population at large (*7*) are:

Cr^{51}, 670,000 pc/liter; Ru^{106}, 3,300 pc/liter; Zr^{95}, 20,000 pc/liter; Zn^{65}, 10,000 pc/liter; P^{32}, 7,000 pc/liter.

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Section IV—Other Data

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U. S. Atomic Energy Commission receives from its contractors periodic reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 23 AEC installations have appeared periodically in *RHD* since November 1960. Following are reports for Paducah Plant, Pinellas Peninsula Plant, and the Savannah River Plant.

Releases of radioactive materials from these installations for the periods covered in the reports below are governed by standards set forth in appropriate chapters of the AEC manual. The radioactivity concentration limits applicable to effluents released from AEC installations are identical to those published in the Federal Register (*1*).

1. Paducah Plant, January–June 1964

Union Carbide Nuclear Company
Paducah, Kentucky

The Paducah Plant is a Government-owned gaseous diffusion plant operated by Union Carbide Corporation Nuclear Division for the Atomic Energy Commission. The diffusion plant, with the associated uranium hexafluoride manufacturing plant and uranium metal foundry, processes large quantities of relatively pure uranium compounds. The major sources of external penetrating radiation are the uranium daughter products, thorium-234, and protactinium-234, which are concentrated in the ash produced during the fluorination process. The element uranium can be a physiological hazard only if allowed to enter the body. The chemical toxicity of the uranium processed at the Paducah Plant overshadows any probable biological effects of radiation from this element, thus making it comparable as a physiological hazard to lead, mercury, or other well-known heavy metals.

Uranium is a rather expensive element, and this provides a great incentive to recover as much in any situation as is feasible. The added desire to maintain a wholesome relationship with neighboring communities and individuals makes it essential that all entrained dust be filtered from exhaust systems, and that all effluent waters be maintained at extremely low concentrations of uranium.

Since no recovery process or filtering system is 100 percent efficient, an environmental monitoring program is required to evaluate the effectiveness of such measures. The Paducah Plant environmental monitoring program provides for continuously sampling the air at 4 stations around the plant perimeter fence, at 5 stations located approximately 1 mile outside this fence, and at 4 stations located 5 miles from the plant. Big Bayou Creek water is sampled continuously, and grab samples are collected at 5 locations in the Ohio River. In addition, gamma radiation readings are taken at each of the air sampling stations with a Geiger-Mueller type meter at a distance of 3 feet above ground level.

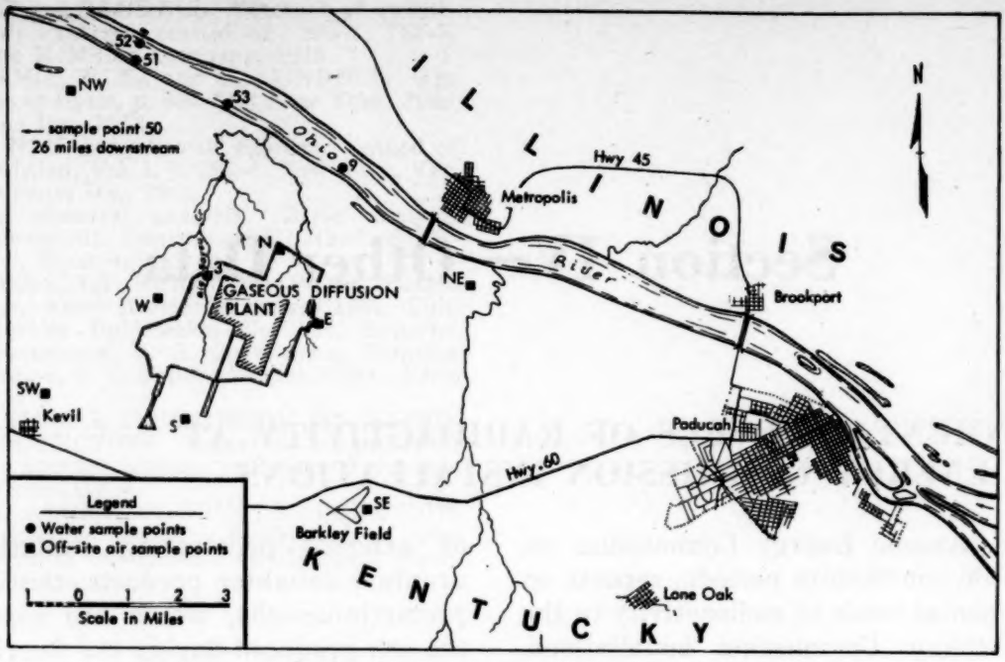

FIGURE 1.—SAMPLING LOCATIONS, PADUCAH PLANT

Basic Standards

The standards observed at the Paducah Plant for exposure to radiation and radioactive materials, both for the in-plant work environment of employees and for off-site exposure of the general population, are those listed in AEC Appendix 0524 which are in turn based on those documented by the Federal Radiation Council in the Federal Register (*1*) on May 18, 1960, and by the National Committee on Radiation Protection in NBS Handbook 69 (*2*). Guidance on general principles of control applicable to all radionuclides occurring in the environment is contained in Report No. 2 of the Federal Radiation Council (*3*). (The references follow Savannah River Plant report).

The standards specify that the radiation or radioactive materials outside a controlled area, and which have resulted from operations within the controlled area, shall be such that it is improbable that any individual may receive a dose of external radiation greater than 0.5-rem in any year. To meet this standard the average concentration of radioisotopes in air or water beyond a controlled area should not exceed one-tenth of the maximum permitted for occupational exposure of 168 hours per week. For the purposes of such control, the concentrations of such radionuclides in air or water may be averaged over periods of time up to 1 year.

Discussion of Data

Data summarizing the environmental concentrations of radioactive materials in air and water and the gamma radiation levels in the vicinity of the Paducah Gaseous Diffusion Plant are presented in tables 1 through 5.

TABLE 1. OUTDOOR URANIUM AIR SAMPLES, FIRST HALF OF 1964

Sample location [a]	No. of samples	Uranium alpha,[b] (pc/m³)			Mean as percent of RCG [d]
		Max.	Min.[c]	Mean	
AT PLANT PERIMETER FENCE					
N	26	0.19	<0.02	0.039	2.0
E	26	0.25	<0.02	0.027	1.4
S	26	0.05	<0.02	0.013	0.7
W	26	0.06	<0.02	0.013	0.7
Totals	104	0.25	<0.02	0.023	1.2
ABOUT ONE MILE OUTSIDE PLANT PERIMETER FENCE					
N	26	0.037	<0.02	0.013	0.7
E	26	0.028	<0.02	0.01	0.5
S	26	0.033	<0.02	0.012	0.6
W	26	0.019	<0.02	0.007	0.4
SE	26	0.033	<0.02	0.008	0.4
Totals	130	0.037	<0.02	0.01	0.5
ABOUT FIVE MILES OUTSIDE PLANT PERIMETER FENCE					
SW	26	0.033	<0.02	0.011	0.6
NW	26	0.128	<0.02	0.023	1.2
NE	26	0.122	<0.02	0.024	1.2
SE	26	0.067	<0.02	0.019	1.0
Totals	104	0.128	<0.02	0.019	1.0

[a] See map in figure 1.
[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.49×10^4 alpha dis/sec.
[c] The minimum detectable uranium in air is 0.02 pc/m³.
[d] The RCG for natural uranium in air beyond a controlled area is 2 pc/m³. (AEC Appendix 0524, Annex 1, table II.).

TABLE 2. OUTDOOR BETA AIR SAMPLES, FIRST HALF OF 1964

Sample location [a]	No. of samples	Beta (pc/m³)			Means as percent of RCG [c]
		Max.	Min.[b]	Mean	
AT PLANT PERIMETER FENCE					
N	26	11	0.4	4.1	0.4
E	26	6	0.4	2.5	0.3
S	26	2.7	<0.075	1.2	0.1
W	26	5	0.4	1.5	0.2
Totals	104	11	<0.075	2.3	0.2
ABOUT ONE MILE OUTSIDE PLANT PERIMETER FENCE					
N	26	3	0.4	1.5	0.2
E	26	3	0.4	1.3	0.1
S	26	3	0.4	1.3	0.1
W	26	3	0.4	1.2	0.1
SE	26	3	0.4	1.2	0.1
Totals	130	3	0.4	1.3	0.1
ABOUT FIVE MILES OUTSIDE PLANT PERIMETER FENCE					
SW	26	2	0.4	1.2	0.1
NW	26	3	0.9	1.5	0.2
NE	26	3	0.4	1.5	0.2
SE	26	3	0.4	1.3	0.1
Totals	104	3	0.4	1.4	0.1

[a] See map in figure 1.
[b] The minimum detectable amount of beta emitters in air is 0.075 pc/m³.
[c] The RCG applicable to this table is 1,000 pc/m³, this number is the RCG for thorium-234, the daughter product of U-238. Insignificant amounts of other daughters are present in freshly refined uranium.

TABLE 3. CONCENTRATION OF URANIUM IN WATER, FIRST HALF OF 1964

Sample location [a]	No. of samples	Uranium, (pc/liter)[b]			Mean as percent of RCG [d]
		Max.	Min.[c]	Mean	
BIG BAYOU CREEK 3	26	59	<1	20	0.1
OHIO RIVER 9	5	1	<1	<1	<0.01
Composite of 50, 51, 52, & 53	5	2	<2	<1	<0.01

[a] See map in figure 2.
[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.49 x 10⁴ dis/sec.
[c] The minimum detectable uranium in water is 1 pc/liter.
[d] The RCG for natural uranium in water beyond a controlled area is 20,000 pc/liter. (AEC Appendix 0524, Annex 1, table II).

TABLE 4. CONCENTRATION OF BETA EMITTERS IN WATER, FIRST HALF OF 1964

Sample location [a]	No. of samples	Beta emitters, pc/liter			Mean as percent of RCG [c]
		Max.	Min.[b]	Mean	
BIG BAYQU CREEK 3	26	2100	<100	400	2.0
OHIO RIVER 9	5	700	<100	300	1.5
Composite of 50, 51, 52 & 53	5	1800	<100	400	2.0

[a] See map in figure 1.
[b] The minimum detectable amount of beta emitters in water is 100 pc/liter.
[c] The RCG for the daughter products of uranium in water beyond a controlled area is 20,000 pc/liter. (AEC Appendix 0524, Annex 1, table II).

Air samples were collected continuously at each of 4 stations at the plant perimeter fence, at 5 stations at about 1 mile outside the plant, and at 4 stations located about 5 miles from the plant. Air is filtered at 0.3 cfm through 2-inch diameter membrane filters which are replaced weekly and counted for alpha and beta activity.

The average alpha count, interpreted as uranium—the most likely source of activity, of the 338 air samples collected was 0.9 percent of the Radioactivity Concentration Guide (RCG) for people residing in the vicinity of a controlled area.

TABLE 5. EXTERNAL GAMMA RADIATION LEVELS FIRST HALF OF 1964

Air sampling location [a]	Total No. of readings	Gamma, mr/hour
AT PLANT PERIMETER FENCE		
N	6	0.02
E	6	0.02
S	6	0.02
W	6	0.02
Totals	24	0.02
ABOUT ONE MILE OUTSIDE PLANT PERIMETER FENCE		
N	6	0.02
E	6	0.02
S	6	0.02
W	6	0.02
SE	6	0.02
Totals	30	0.02
ABOUT FIVE MILES OUTSIDE PLANT PERIMETER FENCE		
SW	6	0.02
NW	6	0.02
NE	6	0.02
SE	6	0.02
Totals	24	0.02

[a] See map in figure 1.

The mean beta count of the 338 samples was 0.18 percent of the RCG for the daughter products of uranium in air beyond a controlled area.

The average uranium analysis of 26 weekly water samples collected by a continuous water sampler in the Big Bayou was 0.1 percent of the RCG for water beyond a controlled area. The uranium analysis of each of 5 samples collected from the Ohio River below the plant at monthly intervals (except during the March flood) was less than 0.02 percent of the RCG. The average beta analysis for the 26 samples from the Big Bayou was 2 percent of the RCG for the decay products of uranium in water beyond a controlled area. The average beta analysis for the 5 samples of Ohio River water down-

stream from the plant was also 2 percent of the RCG when interpreted as uranium daughters. However, similar samples of upstream water averaged 1.5 percent of this RCG.

External gamma radiation in the vicinity of the Paducah Plant averaged 0.02 mr/hour at all sampling stations.

Previous coverage in *Radiological Health Data:*

Period	Issue
1959 and first quarter 1960	*December 1960*
Second and third quarters 1960	*March 1961*
Fourth quarter 1960	*July 1961*
First and second quarters 1961	*January 1962*
Third and fourth quarters 1961	*August 1962*
1962	*September 1963*
1963	*July 1964*

2. Pinellas Peninsula Plant, January–June 1964

General Electric Company,
St. Petersburg, Florida

Pinellas Peninsula Plant, shown in figure 2, is an electronic component production facility in the Atomic Energy Commission's Albuquerque Operations Office manufacturing complex. Environmental monitoring includes sampling of a single combined sewer effluent, milk from five local dairy farms, air, and surface water obtained at locations suggested by meteorological conditions and radioactivity discharge concentrations. Except for air samples which may also contain tritium gas, the radioactive portion of the samples is essentially tritium oxide.

Air Monitoring

Air samples are obtained periodically in areas up to 2 miles downwind from the exhaust stack revealed no detectable amounts of tritium gas or tritium oxide. The limit of detection is 9,600,000 pc/m³ of tritium gas or 5,000 pc of tritium oxide per cubic meter of air.

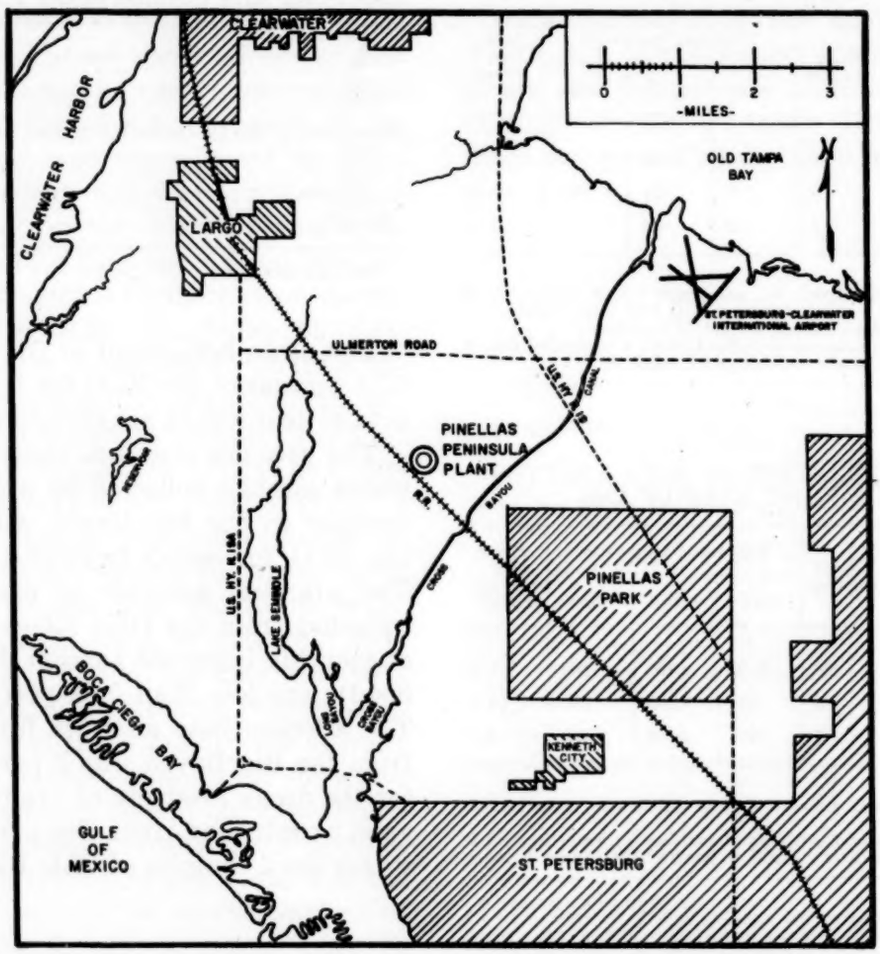

FIGURE 2.—LOCATION OF THE PINELLAS PENINSULA PLANT

Water Sampling

A combined sewer effluent sample is obtained daily from beyond the perimeter of the plant's property. There were no detectable concentrations of tritium oxide (>790,000 pc/liter) in the 128 samples analyzed during the sampling period.

Surface water samples are collected at monthly intervals at selected locations within 8 miles of the plant. The sampling areas are determined by interrelating the concentrations of radioactivity in exhaust stack effluent with meteorological data. There were no indications of tritium (>90,000 pc/liter) in 51 surface water samples analyzed during the sampling period.

Milk Sampling Results

Twenty-four samples of raw milk were collected from farms within a 3-mile radius of the plant. These samples were analyzed by the Florida State Board of Health during 1963. No detectable concentrations (>90,000 pc/liter) of tritium oxide were evident.

Previous coverage in *Radiological Health Data:*

Period	Issue
1960–1961	July 1962
Calendar year 1962	June 1963
Calendar year 1963	September 1964

[1] Expressions in parentheses indicate limits of detectability in the respective environmental samples.

3. Savannah River Plant, January–June 1964

E. I. du Pont de Nemours
Aiken, South Carolina

The Savannah River Plant (SRP), built and operated for the Atomic Energy Commission by E. I. du Pont de Nemours and Company, occupies an area of 312 square miles along the Savannah River, 22 miles downstream from Augusta, Georgia. Production facilities include a Fuel Preparation area, five Reactors, two Fuel Separation areas, and a Heavy Water Production plant. A basic goal in plant operation is total containment of radioactive waste. Although some very low level gaseous and liquid wastes are discharged to the environment in controlled releases, dispersal is adequate to insure environmental concentrations below recommended guides.

The Du Pont Health Physics Section has maintained a continuous monitoring program since 1951 (prior to plant startup) to determine the concentrations of radioactive materials in a 1200-square mile area outside the plant. Included in this area are parts of Aiken, Barnwell, and Allendale counties in South Carolina, and Richmond, Burke, and Screven counties in Georgia. This surveillance determines the magnitude and origin of any radioactivity above natural levels. Measured concentrations of radionuclides in air, water, and milk are compared with the Maximum Permissible Concentrations (MPC) recommended by the International Commission on Radiological Protection (ICRP), or the Daily Intake Guides recommended by the Federal Radiation Council (FRC).

Sensitive instruments, which can detect traces of radioactive materials far below concentrations of hazard significance, are used to determine radioactivity in the environs. Plant-released radioactivity cannot readily be distinguished from weapons tests fallout and both are included in the reported concentrations; maximum and minimum values given are for individual samples collected during the report period.

Atmospheric Monitoring

Concentrations of radioactive materials in the atmosphere were measured by weekly analyses of air filters collected at five monitoring stations located on the plant perimeter and ten stations around a circle of about 25 miles radius from the center of the plant (see figure 3). Deposition rates of radioactive materials at each station were also determined by monthly analyses of rainwater ion-exchange columns (fallout collectors). The monitoring stations are spaced so that a significant plant release of airborne activity would be detected regardless of the prevailing wind. All stations operate continuously. Four additional air monitoring stations at Savannah and Macon, Georgia, and at Columbia and Greenville, South Carolina, are so distant from the plant that

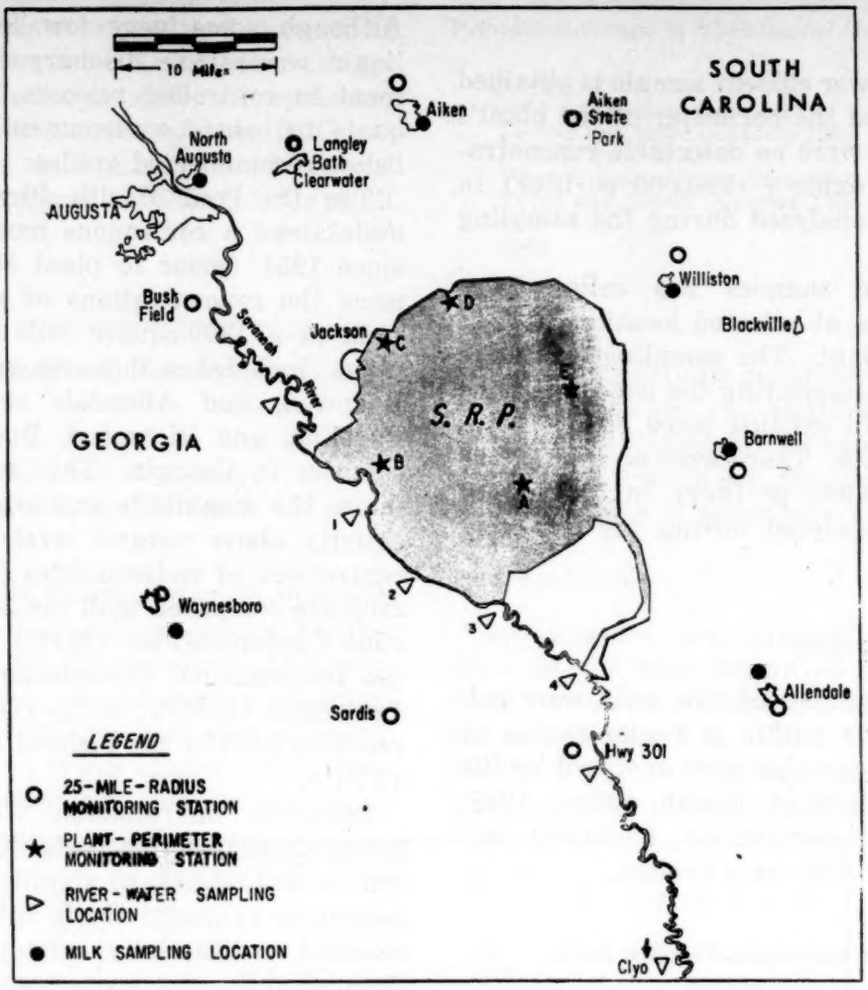

FIGURE 3.—ENVIRONMENTAL SAMPLING LOCATIONS, SAVANNAH RIVER PLANT

the effect of SRP operations is negligible; they are reference points for determining background activity levels (see figure 4). This system permits comprehensive surveillance of atmospheric radioactivity and also makes it possible to differentiate between weapons test fallout and plant releases.

The small amount of radioactive materials released to the atmosphere from the Fuel Separations areas was obscured by fallout from nuclear weapons tests. The influence of the weapons tests which resumed in September 1961 are shown in figure 5. Even though the atmospheric weapons test moratorium began in December 1962, airborne radioactivity continues to remain above the pre-September 1961 concentrations. The rise in levels of airborne radioactivity in early 1964 was the result of the anticipated spring increase in the mixing of stratospheric debris into the troposphere.

Radioactivity in air, determined from filter analyses, is shown in table 6. The January-June 1964 concentrations of beta activity (1.1 pc/m ^{3}) and alpha activity (0.001 pc/m ^{3}) in air were 1.1 percent and 2.5 percent of the respective MPC. Iodine-131 concentrations in air samples were less than 0.02 pc/m ^{3}, the lower detection limit. The relative abundance of airborne radionuclides since January 1963 is shown in figure 6. The diminishing activity is proportional to the areas of the circles which show average activity for each six-month period. Aging of the fallout is seen from increasing percentages of the longer-lived radionuclides Sr ^{90}, Cs ^{137}, and Ru ^{106}. The concentration of beta activity in air was 40 percent below the preceding 6-month period, but because of a combination of unusually high rainfall and increased tropospheric radioactivity during the spring months, the amount of radioactivity de-

TABLE 6.—RADIOACTIVITY IN AIR

(Filter analyses)

	Plant-perimeter locations						25-mile-radius locations									
	A	B	C	D	E	Avg	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush-Field	Highway 301	Langley	Sardis	Waynesboro	Williston	Avg
Alpha Emitters in Air pc/m³ (multiply by 10⁻³)[a]																	
Max	1.5	1.6	2.6	2.0	2.0		2.2	1.6	2.4	1.7	1.6	1.4	2.4	2.5	1.9	1.8	
Min	0.5	0.5	*	0.3	*		*	0.4	0.4	0.1	0.4	0.5	0.5	0.4	0.4	0.6	
Avg	1.0	1.0	1.3	0.9	1.0	1.0	1.1	0.8	1.1	0.9	1.0	0.8	1.4	1.2	1.0	1.2	1.0
Nonvolatile Beta Emitters in Air (pc/m³)[b]																	
Max	1.9	2.1	2.9	1.9	2.0		2.2	2.1	1.9	1.8	2.0	1.6	2.1	1.7	2.0	1.9	
Min	0.6	0.6	0.6	0.5	0.6		0.6	0.4	0.6	0.6	0.5	0.7	0.5	0.6	0.6	0.7	
Avg	1.1	1.1	1.2	1.1	1.1	1.1	1.2	1.1	1.1	1.1	1.1	0.9	1.1	1.1	1.2	1.2	1.1
Specific Radionuclides in Air (Averages) pc/m³																	
Cs^{137}	0.11	0.12	0.14	0.11	0.12	0.12	0.12	0.12	0.11	0.12	0.11	—	0.11	0.11	0.11	0.12	0.11
Ce^{144}	.62	.61	.71	.62	.62	.64	.63	.62	.61	.64	.63	—	.58	.60	.63	.63	.62
Ru^{106}	.53	.54	.60	.59	.55	.56	.54	.54	.53	.54	.54	—	.50	.50	.56	.57	.54
$Zr\text{-}Nb^{95}$	.13	.13	.15	.13	.14	.14	.13	.13	.13	.13	.13	—	.12	.13	.13	.13	.13
Mn^{54}	0.09	0.07	0.08	0.09	0.07	0.07	0.08	0.08	0.07	0.08	0.08	—	0.07	0.08	0.10	0.08	0.08

	Distant air-monitoring locations									
	Columbia, S.C.	Greenville, S.C.	Macon, Ga.	Savannah, Ga.	Avg	Columbia S.C.	Greenville, S.C.	Macon, Ga.	Savannah, Ga	Avg
Alpha Emitters in Air, pc/m³ (multiply by 10⁻³)[a]						Nonvolatile Beta Emitters in Air (pc/m³)[b]				
Max	2.7	2.1	3.0	2.9		2.0	2.3	1.8	2.8	
Min	0.5	0.4	0.4	0.2		0.6	0.5	0.5	0.4	
Avg	1.2	1.0	1.2	1.2	1.2	1.1	1.1	1.1	1.2	1.1
Specific Radionuclides in Air (Averages), pc/m³										
Cs^{137}	0.11	0.11	0.11	0.11	0.11					
Ce^{144}	.58	.62	.60	.60	.60					
Ru^{106}	.49	.52	.52	.51	.51					
$Zr\text{-}Nb^{95}$	.12	.12	.13	.12	.12					
Mn^{54}	0.07	0.07	0.07	0.07	0.07					

[a] MPC=40; Sensitivity of analysis, 0.3.
[b] MPC=100; sensitivity of analysis, 0.006.
* Less than sensitivity of analysis.

posited on the ground was relatively unchanged. Deposition of radioactive materials during the first half of 1964 totaled 366 mc/sq mi at plant perimeter locations and 343 mc/sq mi at 25-mile radius locations; comparable values for the last half of 1963 were 250 mc/sq mi and 390 mc/sq mi. Deposition at each sampling location is recorded in table 7.

Vegetation

Radioactive contamination of vegetation may result from direct deposition on exposed surfaces or from sorption of radioactivity from the soil. Bermuda grass was selected for analysis because of its importance as a pasture grass for daily herds and its availability during all seasons of the year.

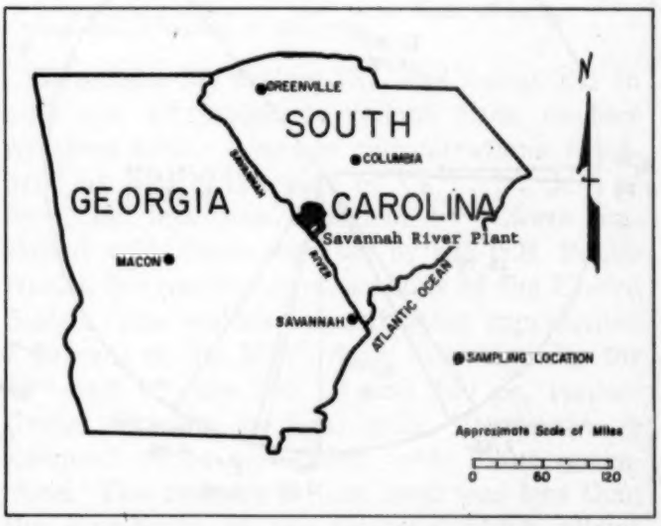

FIGURE 4.—DISTANT AIR MONITORING STATIONS, SAVANNAH RIVER PLANT

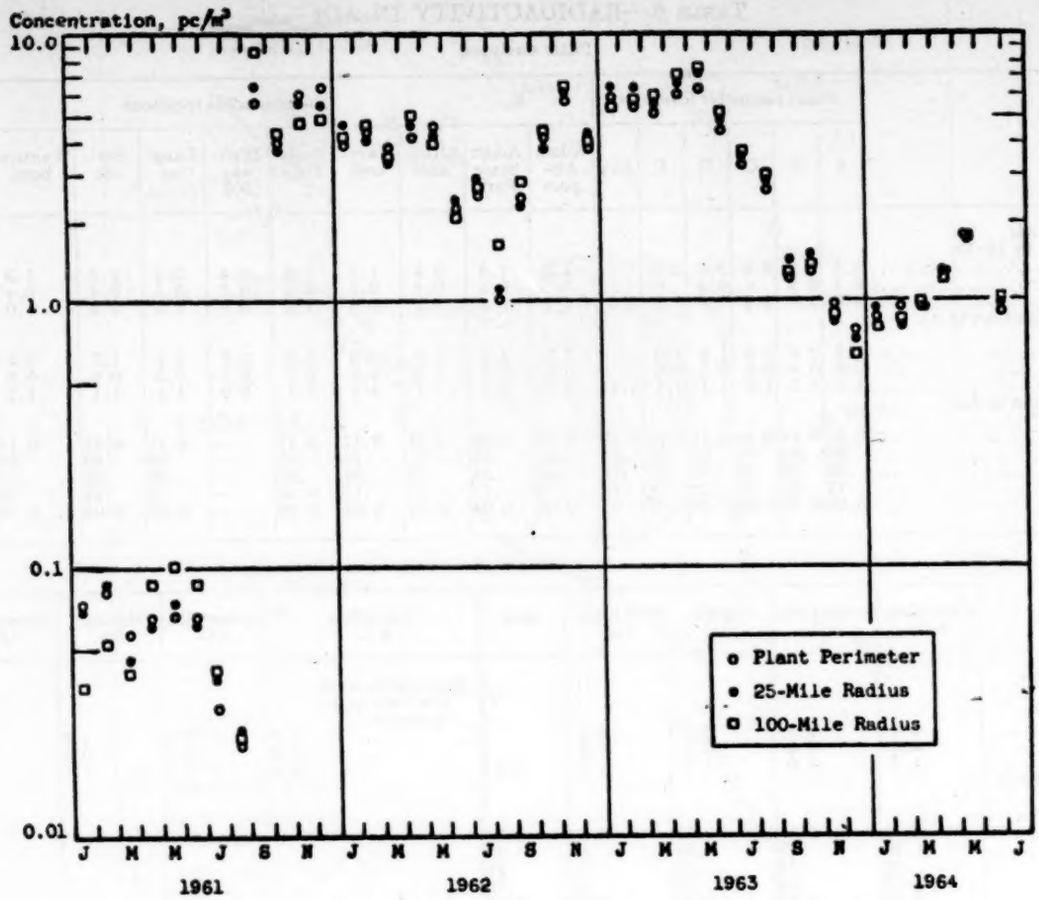

FIGURE 5.—FILTERABLE BETA RADIOACTIVITY IN AIR

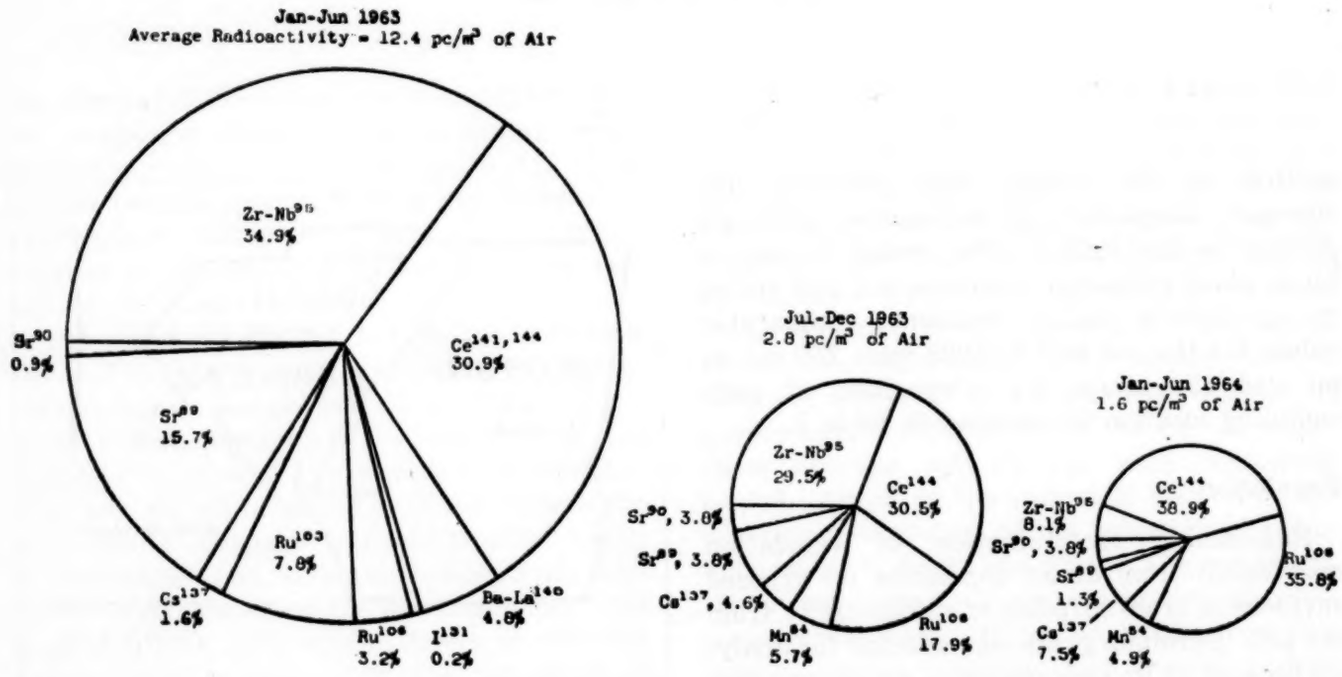

FIGURE 6.—RELATIVE ABUNDANCE OF AIRBORNE RADIONUCLIDES (WEAPONS TEST FALLOUT)

TABLE 7.—TOTAL FALLOUT DEPOSITED

(mc/sq mi)

Radionuclide	Plant-perimeter locations						25-mile-radius locations								
	A	B	C	D	E	Avg	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Avg
Alpha [a]	11.7	15.9	11.5	13.6	14.1	13.3	22.5	12.6	14.6	10.3	22.0	13.9	14.1	17.5	15.0	15.8
I^{131}	[b] *	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sr^{89}	2.5	*	*	*	*	0.5	*	4.4	4.7	1.0	4.1	*	*	*	1.3	1.7
Sr^{90}	20	35	28	36	28	30	32	18	17	20	25	37	21	30	25	25
Cs^{137}	32	37	35	38	38	36	42	31	28	25	47	40	31	32	33	34
Ce^{144}	117	133	123	159	145	135	182	84	94	88	172	139	124	144	106	126
Ru^{103}	11	13	15	15	16	14	14	7	11	7	16	14	12	11	11	11
Ru^{106}	87	101	69	94	98	90	107	84	73	64	118	92	85	101	77	86
Zr-Nb^{95}	35	37	28	31	39	34	44	24	27	29	45	47	31	41	41	35
Mn^{54}	23	27	26	26	28	26	30	21	20	20	30	25	23	22	26	24

[a] Multiply by 10^{12}

[b] *Less than sensitivity of analysis.

Grass samples were collected at 14 locations along the plant perimeter and at 14 other locations along a 25-mile-radius route. (These are not designated on figure 3.) Samples from each quadrant of the plant and of the surrounding area were composited for weekly analysis. Radionuclides in grass samples were from weapons test fallout. Alpha emitters averaged 0.3 pc/gram at plant perimeter and 25-mile radius locations; gamma emitters averaged 200 pc/gram and 187 pc/gram, respectively. Radiosotopic concentrations comprising gamma activity are presented in table 8. The slightly higher levels during January-June 1964 over July-December 1963 (approximately 2-fold for alpha emitters and 1.3-fold for gamma emitters) correspond to the expected seasonal variation.

TABLE 8. RADIOACTIVITY ON VEGETATION

(pc/g)

	Alpha	Cs^{137}	Ce^{144}	Ru^{103}	Ru^{106}	Zr-Nb^{95}	Mn^{54}
Sensitivity of analysis	0.10	0.07	0.32	0.08	0.45	0.06	0.05
Plant Perimeter (14 locations)							
Maximum	1.25	42	280	7	32	29	21
Average	0.28	18	140	3	15	12	12
25-Mile Radius (14 locations)							
Maximum	1.06	35	250	6	30	19	18
Average	0.34	15	130	3	17	11	11

Milk

Milk was sampled at four dairies within a 25-mile radius of the Plant, as shown in figure 3. Samples were taken weekly and analyzed for tritium, radioiodine, and radiocesium. Strontium-90 determinations were made quarterly. Milk produced in the area and sold by major distributors was also analyzed for these radionuclides. Results from analyzing milk for radioactivity during January-June 1964 are in table 9; radioiodine concentrations were all less than the sensitivity of the analysis.

TABLE 9. RADIOACTIVITY IN MILK

	Local dairies				Major distributors [a]
	Aiken	Allendale	North Augusta	Waynesboro, Georgia	
Tritium, pc/l [b]					
Maximum	8000	5000	7000	6000	6000
Minimum	[c] *	*	*	*	*
Average	*	4000	*	*	*
Strontium[90], pc/l [d]					
Feb 1964	25	34	29		30
June 1964	21	31	34		33
Cesium[137], pc/l [e]					
Maximum	188	195	189	219	213
Minimum	90	78	99	91	114
Average	127	110	124	133	146

[a] Milk produced in local dairies but sold by major distributors.

[b] MPC: 300,000: Sensitivity of Analysis: 3000.

[c] *Less than sensitivity of analysis.

[d] Sensitivity of Analysis: 1.0. Daily Intake Guide: 200 pc/day.

[e] Sensitivity of Analysis: 25 MPC: 2000.

Strontium-90, cesium-137, and iodine-131 in milk are attributed to fallout from nuclear weapons tests. Average concentrations measured at SRP (128 pc/l of Cs^{137}, 30 pc/l of Sr^{90}, and less than 5 pc/l of I^{131}) were consistent with those reported by the U.S. Public Health Service for most sections of the United States. The cesium concentration represented 6 percent of the MPC; daily intake guides for Sr^{90} and I^{131} are 200 pc and 100 pc, respectively. Tritium in local milk, if present, is assumed to be associated with Plant operations. The average tritum level was less than the sensitivity of the analysis which allows detection of concentrations equivalent to 1 percent of the MPC.

Algae and Fish in Savannah River

Fish (predominantly bream) and indigenous algae, primarily green (*Vaucheria*) and blue-green (*Phormidium*), were collected weekly upstream, adjacent, and downstream from the plant. Determination of radionuclides in algae is important because algae concentrate certain radionuclides and also because of the role of algae in the food chain of aquatic organisms. Data from analysis of fish and algae samples are in table 10. Beta concentrations in algae adjacent to and downstream from the plant indicate some plant contribution; however, no plant effects were observed in the edible portion of fish from these locations.

Water Monitoring

The plant site is drained by five streams which empty into the Savannah River within the plant boundary (see figure 7). The city of Savannah, 130 miles downstream, gets part of its domestic water supply from the river. With this exception, the river between SRP and the Atlantic Ocean is not used for either irrigation or public drinking water.

Communities near the plant get domestic water from deep wells or surface streams. Public water supplies from 14 surrounding towns were collected and analyzed monthly; concentrations of alpha activity (1.4 pc/l) and beta activity (7 pc/l) were essentially the same as those observed before plant startup in 1951. Data from analyses of all public water samples are in table 11.

River water, analyzed weekly, was sampled continuously at five locations (upstream, adjacent to, and as far as 60 miles downstream) as shown in figure 3. Concentrations of alpha and nonvolatile beta emitters in river water for the past year are summarized in table 12; average concentrations of specific radionuclides found in the river water during January-June 1964 are in table 13.

Radionuclides in river water upstream and downstream from the plant during the January-June 1964 period are shown in figure 8; the values represent the total quantities of radionuclides passing the two sampling points. Neptunium-239, iodine-131, and chrominum-51 are the primary gamma-emitting radionuclides from the plant. These nuclides, released mainly from the Reactor areas, decay rapidly (radioactive half-life less than 30 days). With the exception of strontium-89, most longer-lived materials in river water came from nuclear weapons tests. A release of strontium-89 from a Reactor area during January caused a maximum weekly strontium-89 concentration of 28 pc/liter in river water downstream from the plant (intake guide for Sr^{89} is 2,000 pc/day). This concentration was of short duration as evidenced by much lower concentrations in river water the following weeks.

Tritium (H^3), a beta emitter and the most abundant radionuclide released to the river, does not appear in figure 9, but is comparatively presented in table 8. Tritium is produced by neutron irradiation of heavy water moderator in the reactors. Chromium-51, the second most abundant radionuclide released to the river, is produced by neutron irradiation of stable chromium (a component of the stainless steel used in reactor parts). Tritium and chromium-51 are among the least dangerous of all radionuclides because neither concentrates in body tissues; their concentrations in river water were 3.3 percent and 0.002 percent of their respective MPC. Average concentrations of all radionuclides found in river water during January-June 1964, as shown in table 8, were only small fractions of the permissible concentrations.

TABLE 10.—RADIOACTIVITY IN SAVANNAH RIVER AQUATIC SPECIMENS

(Nonvolatile Beta Emitters, pc/g)*

Location	Algae (Dry Weight)				Fish (Wet Weight)						
	Samples	Max	Min	Avg	Samples	Bone			Flesh		
						Max	Min	Avg	Max	Min	Avg
Control (3 miles upstream from plant)	18	145	35	65	13	35	6	20	4	3	4
Along plant boundary	17	380	30	80	22	110	2	22	20	3	5
Highway 301 crossing (10 miles downstream from plant)	18	175	25	75	13	50	10	18	4	3	4

* Sensitivity of analysis: Varied due to differing sample size.

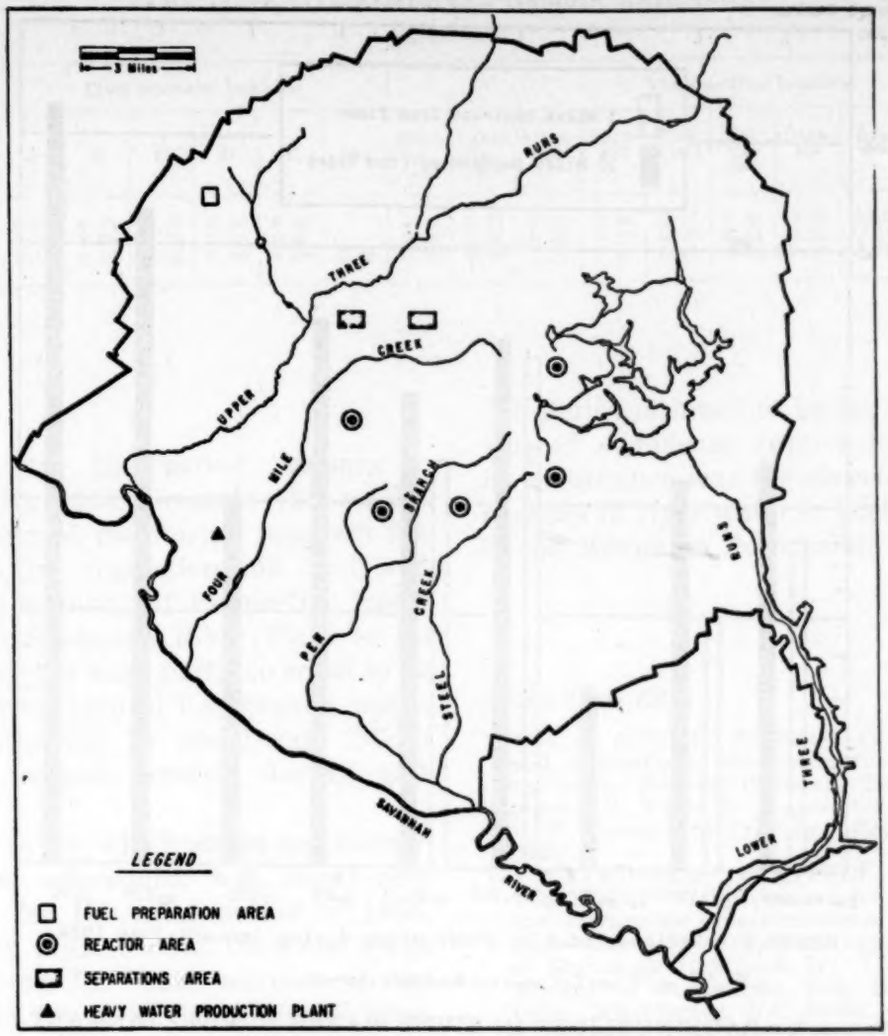

FIGURE 7.—PRODUCTION AREAS AND EFFLUENT STREAMS, SAVANNAH RIVER PLANT

Environmental Gamma Radiation Levels

Monthly measurements of environmental gamma radiation were made with portable Geiger-Mueller survey instruments. January-June 1964 data in table 14 are characteristic of individual station observations during the past several years; the readings are not precise but are sufficiently accurate to illustrate any significant variations above background. The differences among the values shown are within the variance anticipated due to differences in normal background and in instrument response characteristics.

TABLE 11.—RADIOACTIVITY IN PUBLIC WATER SUPPLIES

	Aiken	Allendale	Augusta	Barnwell	Bath	Blackville	Clearwater	Jackson	Langley	New Ellenton	North Augusta	Sardis	Waynesboro	Williston	Avg
Alpha Emitters, pc/l [a]															
Max	3.1	0.4	*	0.2	3.3	0.6	0.3	14.0	2.4	4.3	0.2	0.4	0.2	2.1	
Min	0.5	[b] *	*	*	0.9	*	*	5.4	1.6	0.6	*	*	*	0.6	
Avg	1.8	*	*	*	2.2	0.3	*	9.6	1.9	1.6	*	*	*	1.3	1.4
Nonvolatile Beta Emitters, pc/l [c]															
Max	10	4	9	*	16	10	9	48	9	13	9	7	13	6	
Min	*	*	*	*	5	*	*	12	*	*	*	*	4	*	
Avg	7	*	6	*	7	5	7	24	6	7	5	*	6	*	7

[a] MPC: 10: Sensitivity of analysis: 0.2.
[b] *Less than sensitivity of analysis.
[c] MPC: 3000: Sensitivity of analysis: 4.0.

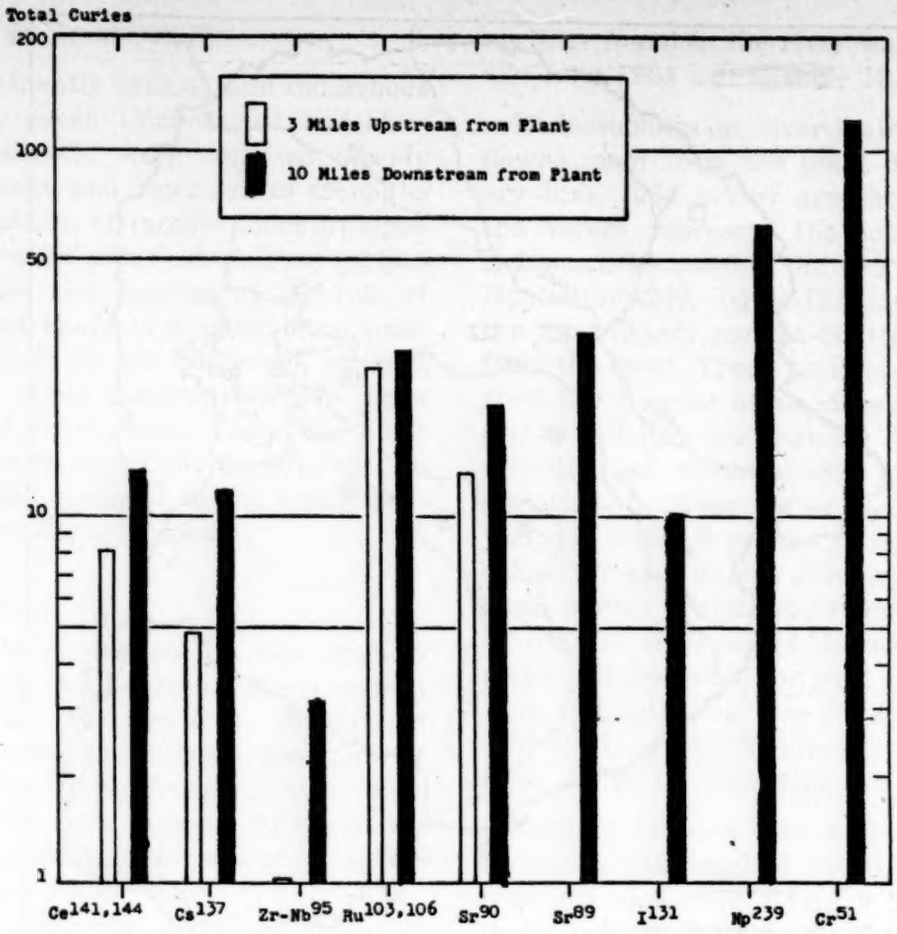

FIGURE 9.--Radionuclides in river water during January-June 1964. Sr^{89}, I^{131}, Np^{239}, and Cr^{51} were not detectable upstream.

FIGURE 8.—RADIONUCLIDES IN RIVER WATER DURING JANUARY–JUNE 1964 (Sr^{89}, I^{131}, Np^{239}, and Cr^{51} were not detectable upstream)

TABLE 12. RADIOACTIVITY IN SAVANNAH RIVER WATER

	Control (3 miles upstream from plant)	Plant perimeter		Highway 301 (10 miles downstream from plant)	Clyo (60 miles downstream from plant)
		1	2		
Alpha Emitters, pc/l [a]					
Jan-June 1964					
Max	0.8	1.5	0.1	0.7	1.1
Min	[b] *	*	*	*	*
Avg	0.3	0.6	0.2	0.3	0.3
July-Dec 1963 Avg	*	*	*	*	*
Nonvolatile Beta Emitters, pc/l [c]					
Jan-June 1964					
Max	21	36	72	54	39
Min	7	5	8	8	9
Avg	12	20	21	21	19
July-Dec 1963 Avg	14	26	29	20	15

[a] MPC: 10; Sensitivity of Analysis: 0.2.
[b] * Less than sensitivity of analysis.
[c] MPC: 3000; Sensitivity of Analysis: 4.0.

TABLE 13. AVERAGE CONCENTRATION OF RADIONUCLIDES IN SAVANNAH RIVER WATER

(Concentration, pc/l)

Radionuclide	Sensitivity of analysis	Control (3 miles upstream from plant)	Highway 301 (10 miles downstream from plant)	Percent MPC at highway 301
H^3	600	1200	10,000	3.3
$Ru^{103, 106}$	3.2	6.1	6.6	0.22
$Ce^{141, 144}$	2.5	4.0	4.0	0.13
Cs^{137}	0.6	0.8	1.7	0.08
Np^{239}	0.9	[a] *	19.1	0.06
Ba-La^{140}	1.6	—	3.2	0.04
Zr-Nb^{95}	0.5	0.7	0.8	0.004
Cr^{51}	4.3	*	17.4	0.002
Sr^{89}	0.3	*	3.0	[b] **
I^{131}	0.5	*	2.3	**
Sr^{90}	0.01	1.3	2.0	**
Co^{60}	1.4	*	*	—
Zn^{65}	1.1	*	*	—
Mn^{54}	0.4	*	*	—

[a] * Less than sensitivity of analysis.
[b] ** Daily intake guides for Sr^{89}, Sr^{90}, and I^{131} are 2000 pc/day, 200 pc/day, and 100 pc/day, respectively.

TABLE 14.—ENVIRONMENTAL GAMMA RADIATION

(mr/24 hours)

	Plant perimeter locations						25-mile-radius locations									
	A	B	C	D	E	Avg	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Highway 301	Langley	Sardis	Waynesboro	Williston	Avg
Max	0.46	0.44	0.49	0.45	0.45		0.44	0.44	0.38	0.54	0.47	0.43	0.39	0.43	0.40	0.42	
Min	0.36	0.36	0.35	0.35	0.31		0.32	0.30	0.33	0.33	0.36	0.35	0.31	0.35	0.32	0.33	
Avg	0.41	0.40	0.42	0.40	0.39	0.40	0.39	0.36	0.36	0.40	0.41	0.38	0.37	0.38	0.36	0.38	0.38

Summary

This report, for the period January 1 through June 30, 1964, presents the results of the environmental monitoring program for the atmosphere, for vegetation and food, and for water. The quantity of radioactive waste released by the Savannah River Plant to its environs was, for the most part, too small to be distinguished from natural background radiation, or was obscured by world-wide fallout from nuclear weapons testing during past years.

Beta activity in air, which shows no relationship with plant operations, was about one-eighth of that for the same period of 1963. Radionuclides in milk were at the same levels as those reported for most sections of the United States by the U. S. Public Health Service. The concentration of radioactive materials in river algae indicated some slight contribution from the plant. Radioactive materials in fish flesh continued to be far below levels considered significant from a health standpoint. In no instance was the concentration of radionuclides in river water in excess of 3.3 percent of the Maximum Permissible Concentration.

REFERENCES

(1) U. S. ATOMIC ENERGY COMMISSION. Rules and regulations, standards for protection against radiation. Federal Register. Title 10, Part 20, Appendix B, Table 2. Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402.

(2) NATIONAL COMMITTEE ON RADIATION PROTECTION. Maximum permissible body burdens and permissible concentrating of radionuclides in air and water for occupational exposure. Natl. Bureau of Standards Handbook 69: (June 1959), Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(3) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2 (September 1961) Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

REPORTED NUCLEAR DETONATIONS, JANUARY 1965

During January 1965, the Atomic Energy Commission announced two underground nuclear tests, one of which was a U.S. test, the other being a Soviet test detected through seismic signals. The U.S. test conducted on January 14 at the Nevada Test Site was in the low yield range. The Soviet test detected on January 15 was tracted to the Semipalatinsk area and was in the intermediate yield range. Some evidence of venting connected with the Soviet test has been found by the U.S. detection system, but radioactivity identified with the event was not expected to produce measureable exposures to persons. (Low yield range is defined as less than 20 kilotons and intermediate yield ranges from 200 kilotons to 1 megaton.)

Section I—Air and Fallout

FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess human radiation exposure from fallout, it is widely used as the basis for alerting systems to determine when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form and are also compared in beta concentration isograms.

1. Radiation Surveillance Network November 1964

Division of Radiological Health, Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the Division of Radiological Health, PHS, which regularly gathers samples from 73 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Alerting function

The alerting function of the network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the end of the sampling period to allow for decay of naturally-occurring radon daughters. The network station operators telephone any daily field estimates over 10 pc/m^3 to the Radiation Surveillance Center, Division of Radiological Health, Washington, D. C. Lower field estimates are reported to the Center by the laboratory at Rockville, Maryland, which receives a daily written report together with the air filter submitted by each station operator. The filters are counted at the laboratory to confirm field estimates. Analyses for specific radionuclides may also be made if gross beta activity concentrations are high. All field estimates are reported elsewhere on a monthly basis (*1*). When unusually high air levels are reported, appropriate Federal and State officials are promptly notified.

Air sampling procedure and results

Airborne particulates are collected continuously on carbon-loaded cellulose dust filters 4 inches in diameter. A volume of about 1,800 cubic meters of air is drawn through each filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, where the gross beta activity is measured using a thin-window, gas-flow proportional counter, calibrated with a Sr^{90}–Y^{90} standard. Each filter is counted at least 3 days after the end of the sampling period and again

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING LOCATIONS

7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. By using the two counts and the Way-Wigner formula (*2*), the age of fission products is estimated, and the activity extrapolated to the time of collection.[1] The daily concentrations and estimated ages of selected samples are reported by the PHS in a monthly RSN report (*1*).

Time profiles of gross beta activity in air for eight RSN stations are shown in figure 2.

Precipitation measurements

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by:

$$D = \frac{CP}{1000}$$

where D is the deposition in nc/m², C is the concentration in pc/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month, and the average concentration for the month, $\overline{C}$, is determined by:

$$\overline{C} = \frac{\Sigma D}{\Sigma P} \times 1000$$

The November 1964 average concentrations and total depositions are given in table 1.

[1] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value; consequently the calculated age of the fresh component will be overestimated.

TABLE 1.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, NOVEMBER 1964

Station location		Air surveillance					Precipitation measurement	
		Number of samples[1]	Gross beta activity (pc/m³)			Last profile in *RHD*	Total Depth (mm)[b]	Total deposition (mc/m²)[b]
			Maximum	Minimum	Average[a]			
Ala:	Montgomery	30	2.96	<0.10	0.72	Aug 64	89.6	18.8
Alaska:	Adak	25	0.53	<0.10	0.22	Nov 64		
	Anchorage	28	0.30	<0.10	0.17	Jul 64	69.3	18.1
	Attu	28	0.34	<0.10	0.15	Dec 64		
	Fairbanks	19	0.38	<0.10	<0.14	Aug 64	23.8	6.0
	Juneau	14	0.19	<0.10	<0.14	Sep 64	107.1	40.2
	Kodiak	10	0.59	<0.10	<0.25	Oct 64		
	Nome	15	0.27	<0.10	<0.16	Feb 65		
	Point Barrow	27	0.51	<0.10	0.14	Jan 65		
	St. Paul Island	28	0.39	<0.10	<0.16	Mar 65		
Ariz:	Phoenix	30	1.13	0.24	0.64	Sep 64		
Ark:	Little Rock	26	2.27	<0.10	0.72	Sep 64	105.4	21.1
Calif:	Berkeley	29	0.72	<0.10	0.28	Oct 64	101.7	22.7
	Los Angeles	29	1.31	<0.10	0.48	Feb 65	43.4	8.7
Canal Zone:	Ancon	11	0.72	<0.10	<0.15	Nov 64		
Colo:	Denver	26	1.51	<0.10	0.44	Oct 64	13.9	4.9
Conn:	Hartford	29	0.90	0.14	0.46	Oct 64	54.3	13.5
Del:	Dover	17	1.42	0.26	0.60	Aug 64		
D. C:	Washington	27	1.52	0.11	0.68	Feb 65	17.3	3.5
Fla:	Jacksonville	29	1.73	<0.10	0.59	Sep 64	98.4	25.2
	Miami	29	1.18	<0.10	0.52	Oct 64	35.7	8.7
Ga:	Atlanta	[b]				Jul 64	11.8	9.8
Guam:	Agana	30	1.83	<0.10	<0.22	Apr 64		
Hawaii:	Honolulu	29	0.33	<0.10	<0.15	Dec 64	69.2	16.6
Idaho:	Boise	29	1.01	<0.10	0.36	Dec 64	31.5	11.7
Ill:	Springfield	27	2.19	<0.10	0.63	Feb 65		
Ind:	Indianapolis	13	2.59	0.17	0.98	Jul 64	86.1	17.3
Iowa:	Iowa City	26	1.44	0.13	0.47	Nov 64	33.8	17.3
Kans:	Topeka	26	1.58	<0.10	0.37	Jul 64	101.9	31.6
Ky:	Frankfort	27	2.69	0.15	0.86	Feb 65	47.3	13.2
La:	New Orleans	29	1.82	<0.10	0.46	Feb 65	63.7	16.9
Maine:	Augusta	30	1.43	<0.10	0.39	Mar 64	109.6	27.0
	Presque Isle	15	0.51	<0.10	0.24	Nov 64		
Md:	Baltimore	28	1.12	0.13	0.51	Oct 64	20.0	4.0
	Rockville	14	2.34	0.23	0.87	Jan 65		
Mass:	Lawrence	29	1.44	0.20	0.60	Aug 64	47.6	22.3
	Winchester	28	1.44	0.24	0.62	Dec 64	33.0	12.4
Mich:	Lansing	30	3.12	0.21	0.79	Jan 65	15.6	9.0
Minn:	Minneapolis	21	0.71	<0.10	0.24	Mar 64	31.9	10.3
Miss:	Jackson	25	2.22	<0.11	0.73	Mar 65	152.6	30.6
	Pascagoula	15	2.61	0.13	0.78	Dec 64		
Mo:	Jefferson City	28	1.99	<0.10	0.53	July 64	82.9	16.8
Mont:	Helena	30	1.01	0.12	0.40	Nov 64	14.0	3.2
Nebr:	Lincoln	13	1.26	<0.10	0.50	Mar 65		
Nev:	Las Vegas	24	0.80	<0.10	0.30	Aug 64	7.3	1.5
N. H:	Concord	18	0.90	<0.10	0.47	Feb 65		
N. J:	Trenton	30	1.04	<0.10	0.44	Mar 65	11.2	3.3
N. Mex:	Santa Fe	22	1.20	<0.10	0.41	Nov 64	11.2	2.5
N. Y:	Albany	25	1.38	0.12	0.49	Jul 64	36.9	15.4
	Buffalo	20	1.50	0.14	0.56	Nov 64		
	New York	20	1.16	<0.10	0.81	Dec 64		
N. C:	Gastonia	29	2.28	<0.10	0.82	Nov 64	57.3	14.2
N. Dak:	Bismarck	28	0.82	<0.10	0.29	Jan 65	3.2	1.7
Ohio:	Cincinnati	19	2.40	0.16	0.68	Aug 64		
	Columbus	29	2.13	0.21	0.82	Mar 65	43.1	13.0
	Painesville	30	2.43	0.22	0.88	Oct 64	14.6	6.3
Okla:	Oklahoma City	29	3.26	<0.10	0.55	Jan 65	102.8	33.9
	Ponca City	29	1.60	<0.10	0.31	Oct 64	155.7	43.1
Ore:	Portland	27	1.09	<0.10	0.38	Mar 65	120.3	41.5
Pa:	Harrisburg	30	1.32	0.11	0.47	Jul 64	9.8	3.5
P. R:	San Juan	28	0.43	<0.10	<0.19	Mar 65	75.9	15.2
R. I:	Providence	28	1.08	0.16	0.45	Jan 65	67.1	16.5
S. C:	Columbia	23	2.06	<0.10	0.69	Dec 64	35.5	7.2
S. Dak:	Pierre	28	1.10	<0.10	0.35	Sep 64		
Tenn:	Nashville	30	3.04	<0.10	0.93	Jan 65	105.3	34.0
Tex:	Austin	27	3.65	<0.10	0.62	Aug 64	72.0	29.5
	El Paso	26	1.33	0.11	0.61	Jan 65		
Utah:	Salt Lake City	27	1.28	0.13	0.53	Feb 65	40.4	15.2
Vt:	Barre	30	1.21	<0.10	0.50	Sep 64	52.7	19.6
Va:	Richmond	30	0.97	<0.10	0.48	Sep 64	50.4	10.6
Wash:	Seattle	29	0.66	<0.10	<0.18	Jul 64	201.6	98.5
	Spokane	30	0.67	<0.10	0.22	New		
W. Va:	Charleston	29	2.11	<0.10	0.82	Dec 64	67.4	14.4
Wis:	Madison	30	2.91	0.14	0.63	Sep 64	53.7	27.7
Wyo:	Cheyenne	28	1.14	<0.10	0.39	Aug 64		
Network summary		1,880	3.65	<0.10	•0.48		•53.8	•17.9

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign appears before the average.

[b] Blank indicates no report received.

• Arithmetic average of the station averages.

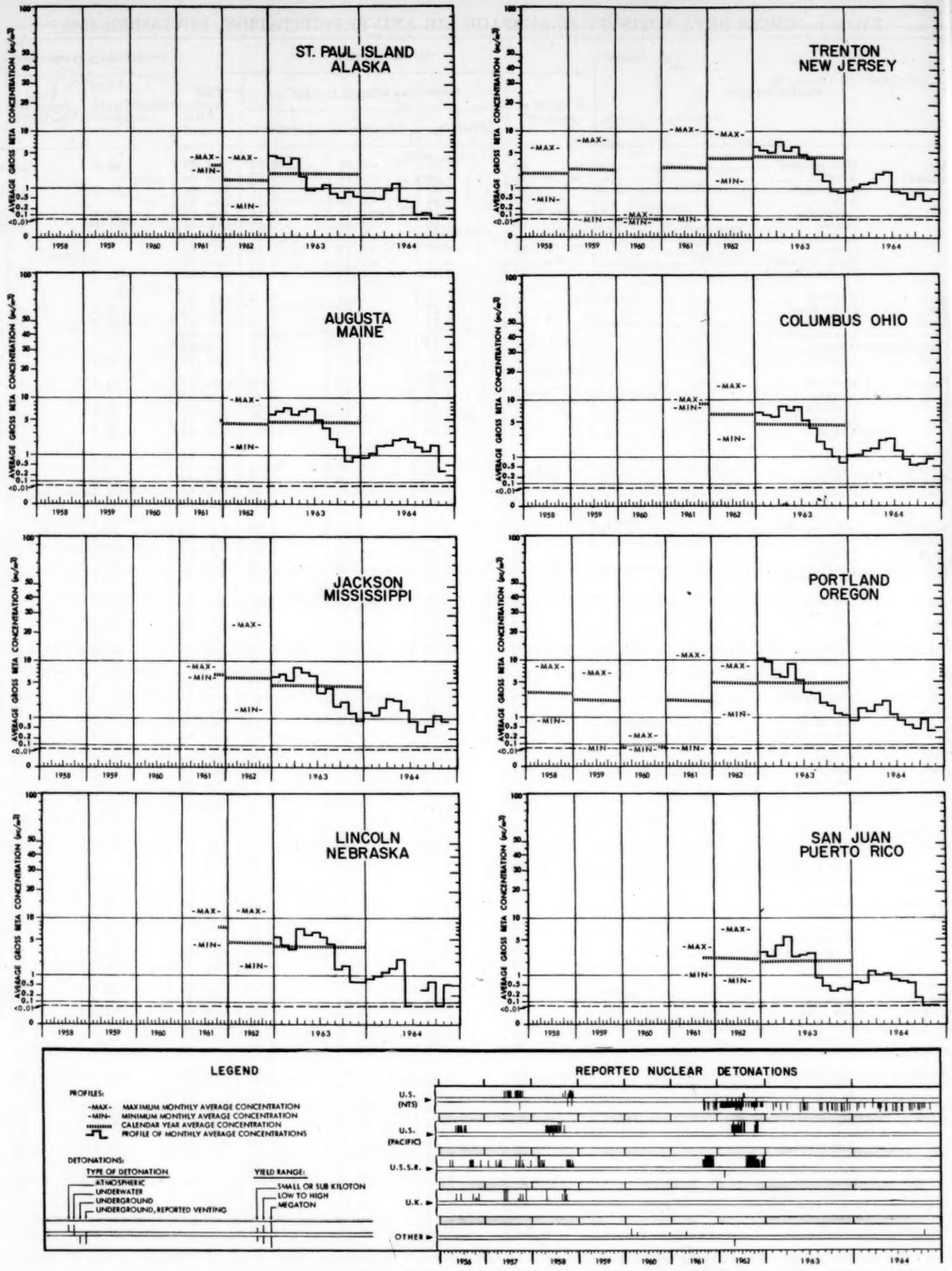

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR—RADIATION SURVEILLANCE NETWORK, 1958–NOVEMBER 1964

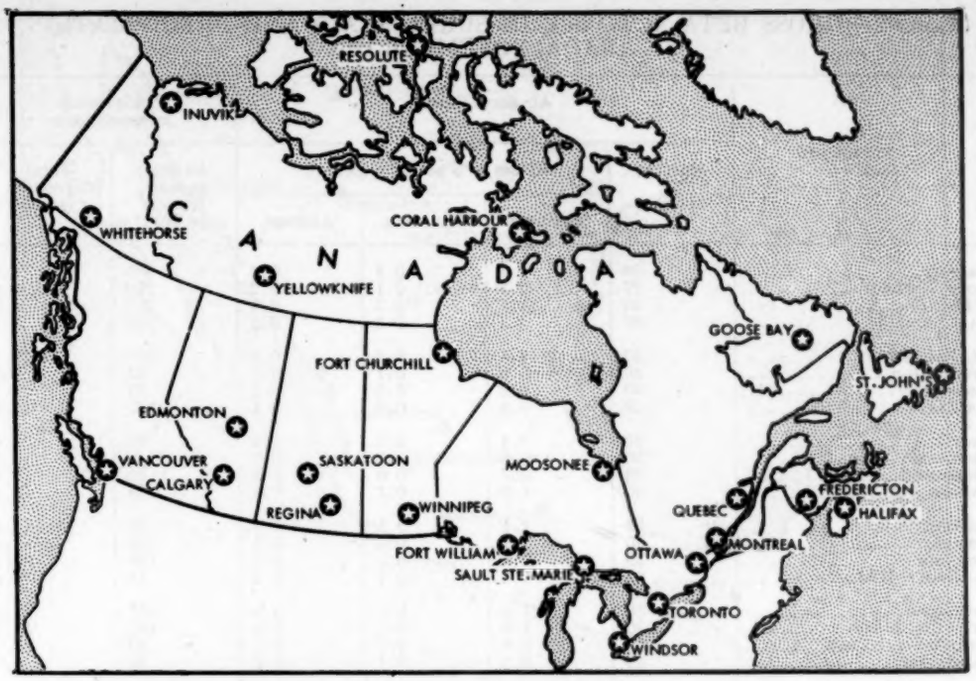

FIGURE 3.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS

2. Canadian Air Monitoring Program [2] November 1964

Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3-7*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter glass fiber filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas-flow, Geiger-Mueller counter system calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for November 1964 are given in table 2 and presented in conjunction with U. S. and Mexican data by an isogram map (figure 5).

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are also added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is ignited together with the polyethylene liner at 450 degrees C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infra-red lamp, and then counted with a thin-end-window Geiger-Mueller counter calibrated with a Sr^{90}–Y^{90} source. Gross beta activities for November 1964 samples are given in table 2. Radionuclide analyses are reported quarterly in *RHD*.

[2] Data from RADIATION PROTECTION DIVISION. *Radiation Protection Program*, Vol. 2, No. 12, 11–24 (December 1964), Canadian Department of National Health and Welfare, Ottawa, Canada.

TABLE 2.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, CANADA, NOVEMBER 1964

Station location	Air surveillance				Precipitation measurements	
	Number of samples	Gross beta activity (pc/m³)			Average concentration (pc/liter)	Total deposition (nc/m²)
		Maximum	Minimum	Average		
Calgary	30	1.7	0.1	0.4	201	4.2
Coral Harbour	29	0.3	0.1	0.2	210	5.3
Edmonton	30	1.7	0.1	0.4	162	6.0
Ft. Churchill	30	0.3	0.1	0.2	120	3.2
Ft. William	30	1.4	0.1	0.3	311	11.1
Fredericton	30	0.6	0.1	0.2	85	6.3
Goose Bay	30	0.5	0.1	0.2	57	3.7
Halifax	29	0.3	0.0	0.1	153	13.5
Inuvik	30	0.4	0.1	0.2	94	1.6
Montreal	30	0.8	0.1	0.3	142	10.5
Moosonee	29	0.5	0.0	0.2	90	7.8
Ottawa	30	1.0	0.1	0.3	103	8.4
Quebec	30	1.1	0.1	0.3	90	11.9
Regina	30	1.1	0.1	0.3	216	2.6
Resolute	30	0.4	0.1	0.2	128	9.5
St. John's, Nfld	28	0.4	0.1	0.2	44	7.8
Saskatoon	30	1.4	0.1	0.3	501	1.9
Sault Ste. Marie	30	1.5	0.1	0.4	100	13.0
Toronto	30	0.6	0.1	0.3	80	3.9
Vancouver	30	0.5	0.1	0.2	56	8.7
Whitehorse	30	0.3	0.1	0.2	47	0.6
Windsor	30	1.8	0.1	0.5	323	7.0
Winnipeg	30	1.4	0.1	0.4	245	3.9
Yellowknife	30	0.5	0.1	0.2	87	1.5
Network summary		0.9	0.1	0.3	152	6.4

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

3. Mexican Air Monitoring Program November 1964

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), Mexico City. From 1952 to 1961 the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*8-12*).

In 1961 the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance network. This network consists of 17 stations (see figure 4), twelve of which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRP operate the station at Mexico City, while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week at the rate of approximately 1,200 cubic meters per day, through a high-efficiency, 6 x 8-inch glass fiber filter, using high volume samplers. After each 24-hour sampling period, the filter is removed and forwarded via air mail to the "Laboratorio de Estudios sobre Contaminación Radiactiva", CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of

FIGURE 4.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

radon and thoron daughter natural radioactivity. Data are not extrapolated to time of collection.

Results

The maximum, minimum, and average fission product beta concentrations in surface air during November 1964 are presented in table 3. The data are also represented in the beta activity isogram map of North America, figure 5.

TABLE 3.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, NOVEMBER 1964

Station	Number of Samples	Gross beta activity (pc/m³)		
		Maximum	Minimum	Average
Acapulco	2	—	—	0.2
Ciudad Juárez	23	1.0	0.1	0.4
Chihuahua	15	1.1	0.1	0.3
Ensenada	10	2.1	0.2	0.7
Guadalajara	10	0.1	0.0	0.1
Guaymas	8	0.6	0.1	0.3
La Paz	15	0.9	0.2	0.5
Matamoros	16	0.9	<0.1	0.3
Mazatlán	9	0.8	<0.1	0.4
Mérida	15	1.9	<0.1	0.4
México, D.F.	16	0.4	<0.1	0.1
Nuevo Laredo	13	1.5	0.1	0.4
San Luis Potosí	13	1.5	<0.1	0.4
Tampico	13	1.4	<0.1	0.3
Torreón	11	1.1	0.1	0.4
Tuxtla Gutiérrez *				
Veracruz	13	3.5	<0.1	0.7

* Blank indicates station temporarily shut down.

4. Pan American Air Sampling Program November 1964

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by four countries in the Americas under the auspices of a collaborative program, developed by the Pan American Health Organization and the Public Health Service (PHS), for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The four air sampling stations included in the Program are operated by the technical staff of the Ministry of Health in each country. The station in Kingston, Jamaica, is operated by the Public General Hospital; in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations; in Lima, Peru, by the Institute of Occupational Health; and in Santiago, Chile, by the Occupational Health Service. The Kingston station began operation in March 1964, and the other three were started near the end of 1962.

The November 1964 air monitoring results from the four participating countries are given in table 4.

TABLE 4.—GROSS BETA ACTIVITY IN AIR, NOVEMBER 1964

[Concentrations in pc/m³]

Sampling stations	No. of samples	Maximum	Minimum	Average [a]
Kingston, Jamaica	19	0.30	<0.10	<0.12
Caracas, Venezuela	21	0.13	<0.10	<0.10
Lima, Peru [b]	—	—	—	—
Santiago, Chile	29	0.26	<0.10	<0.14

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed in front of the average.
[b] No report received.

5. Gross Beta Activity in Air, North America November 1964

Beginning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America. The data from the Radiation Surveillance Network and the Canadian Air Network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*13*).

With the formation of the Mexican Air monitoring program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, Pan American Air Sampling Program, National Air Sampling Network, the HASL 80th Meridian Network, and the Mexican Network (*14*). The new intercalibration factors reflect some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963.

Figure 5 shows the November 1964 activity in air throughout North America based on the data from the Canadian Air Monitoring Program, the Radiation Surveillance Network, the Pan American Air Sampling Program, and the Mexican Air Monitoring program. An intercalibration factor of 1.28 was applied to the RSN and Pan American and the Mexican data were multiplied by 0.81 in order to adjust them to Canadian data.

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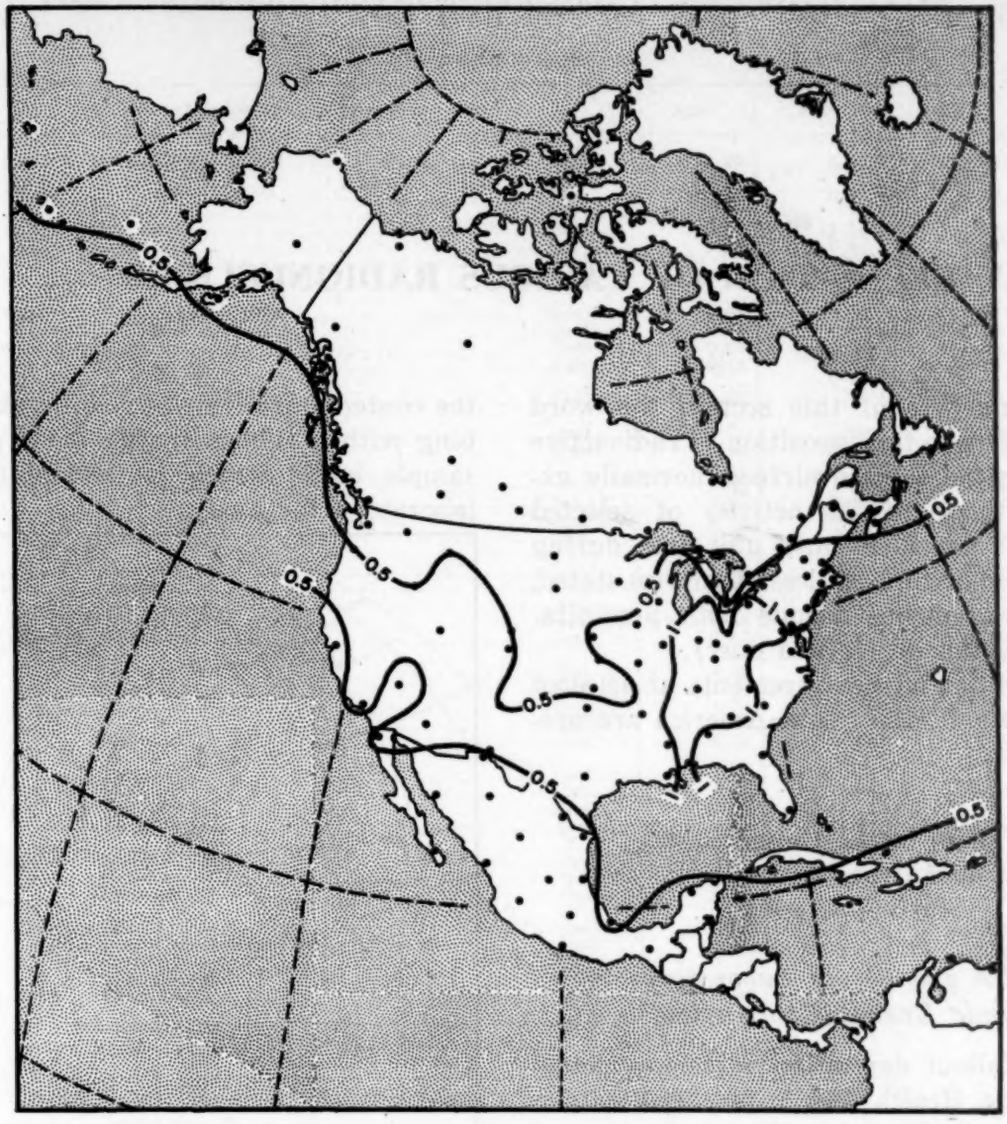

FIGURE 5.—ISOGRAM OF AVERAGE GROSS BETA CONCENTRATIONS IN AIR, NORTH AMERICA, NOVEMBER 1964

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MONTHLY DEPOSITION OF VARIOUS RADIONUCLIDES

For the purpose of this section the word "fallout" refers to the deposition of radioactive materials on the earth's surface, normally expressed in terms of the activity of selected radionuclides deposited on a unit area during a given period of time. Unless otherwise stated, fallout measurements include both precipitation and dry fallout (settled dust).

Reports of fallout measurements at selected stations in North and South America are presented below.

1. Fallout in the United States and Other Areas,[1] April-June 1964

Health and Safety Laboratory
Atomic Energy Commission

Monthly fallout deposition rates are determined by the Health and Safety Laboratory (HASL) for 49 sites in the United States and 107 locations in other countries. HASL data from 38 of the U. S. stations and 24 other selected points in the Western Hemisphere (see figure 1) covering the period from April through June 1964 are summarized below. All the stations of the 80th Meridian Network except Washington, D. C. are represented.

Methods of collection

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout are collected for a period of one month in stainless steel pots with exposed areas of 0.076m^2. At the end of the collection period, the contents are transferred, by careful scrubbing with a rubber spatula, to a polyethylene sample bottle which is then shipped to the laboratory for analysis.

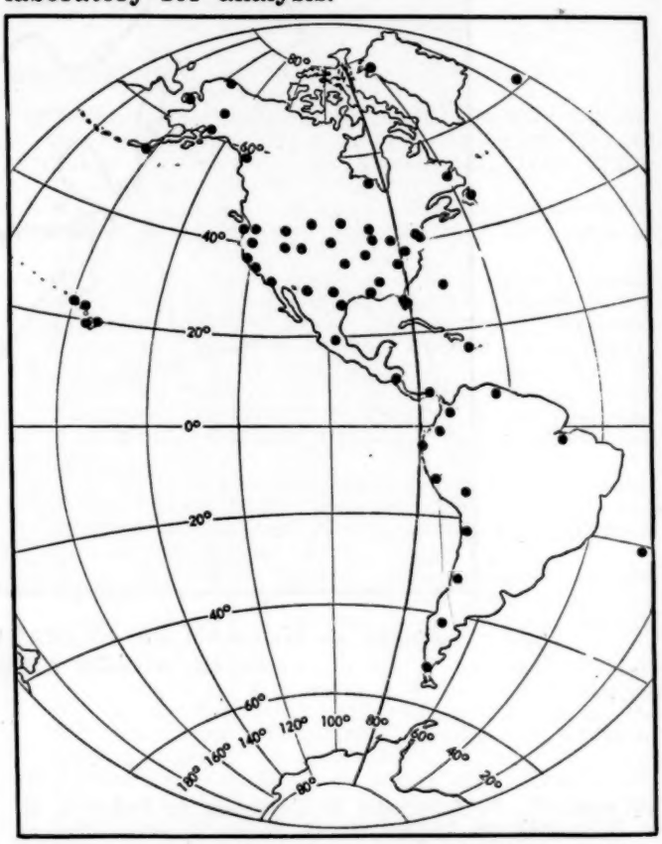

FIGURE 1.—HASL FALLOUT SAMPLING STATIONS

The second method involves the use of a polyethylene funnel, with exposed area of 0.07m^2, attached to an ion exchange column. After a one-month collection, the inside of the funnel is wiped with a tissue and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis. It has been shown that at the 95 percent confidence level there was no significant difference in the strontium-90 measurements obtained from samples collected by the two methods (*1*).

[1] The data in this article were taken from *Fallout Program Quarterly Summary Report, HASL–155*, Health and Safety Laboratory, AEC, New York, New York 10014.

TABLE 1.—MONTHLY STRONTIUM-90 FALLOUT IN THE UNITED STATES, HASL, APRIL–JUNE 1964

[Deposition in nc/m²]

	Sampling location and type of collection	April	May	June
Ala:	Birmingham (pot)	0.29	1.06	2.08
Alaska:	Anchorage (col)	[a] 0.47	0.74	0.57
	Barrow [b] (col)	—	—	—
	Cold Bay (col)	0.87	1.15	1.03
	Fairbanks (col)	0.22	0.44	1.37
	Juneau (col)	[c]	3.93	2.70
	Nome (col)	[c]	0.28	0.03
Calif:	W. Los Angeles (pot)	0.04	0.03	[b]
	Palo Alto [b] (pot)	—	—	—
	Palo Alto (col)	0.07	0.22	0.12
	San Francisco (col)	0.12	0.21	0.17
Colo:	Denver (col)	0.32	1.47	4.58
Fla:	Coral Gables (pot)	[c]	3.04	2.15
	Miami (col)	0.96	2.04	2.00
Hawaii:	Hilo (col)	1.88	6.84	0.25
	Litlue (col)	1.73	0.84	4.40
	Mauna Loa (col)	0.23	0.23	0.01
	Oahu (pot)	1.19	1.19	0.69
Ill:	Argonne (pot)	2.74	1.20	3.22
La:	New Orleans (col)	1.87	0.47	0.94
Minn:	International Falls (col)	1.84	3.05	0.49
Mo:	Columbia (col)	1.68	3.74	1.87
Mont:	Helena (col)	0.46	1.43	2.76
N.J.	Westwood (pot)	2.58	0.86	2.39
	Westwood (col)	[c]	0.80	1.84
N.Y.	New York (pot)	4.74	0.52	2.55
N.D.	Williston (col)	0.29	0.72	2.94
Ohio:	Wooster (pot)	3.14	3.03	3.04
Okla:	Tulsa (pot)	[d] 1.30	[d] 1.60	[b]
Ore:	Medford (col)	0.19	0.35	1.04
S.C.:	Columbia (col)	0.74	1.14	[b]
S. Dak:	Vermillion (pot)	4.22	2.84	4.58
Texas:	Dallas (col)	1.57	2.01	0.61
	El Paso (col)	0.34	0.05	0.19
	Houston (col)	0.38	0.54	0.49
Utah:	Salt Lake City (pot)	5.70	2.31	6.58
Va:	Sterling (U.S. Weather Bureau Station) (col)	1.89	0.71	0.81
Wash:	Seattle (pot)	1.47	1.83	2.56
	Tatoosh Island (col)	0.15	0.91	1.59
Wis:	Green Bay (col)	1.42	1.73	[b]

[a] Lower limit of reported data.
[b] No data reported.
[c] No data available.
[d] Proportioned from originally consolidated data.

Strontium-90

All of the HASL fallout samples—both pot and column—were assayed for strontium-90. The strontium-90 data are given in tables 1 and 2 for selected stations. Where duplicate samples were collected, the average values are given.

Other radionuclides

Laboratories at Palo Alto, California; Westwood, New Jersey; Oklahoma City, Oklahoma; Chattanooga, Tennessee; Seattle, Washington; and Appleton, Wisconsin have analyzed monthly pot samples for various radionuclides. The monthly deposition rates for Sr^{90}, Sr^{89}, Ce^{144}, Cs^{137}, Zr^{95}, Mn^{54} and precipitation depth are presented in tables 1-3.

2. Fallout Measurements in Canada July-September 1964

Department of National Health and Welfare
Ottawa, Canada

The monthly accumulated precipitation samples collected in conjunction with the Canadian air sampling network described earlier in this issue represent total fallout (wet and dry), since they are collected in deep pots lined with polyethylene. The radiochemical analyses of these samples for July through September 1964 are given in table 4.

TABLE 2.—MONTHLY STRONTIUM-90 FALLOUT IN NORTH AND SOUTH AMERICA, HASL, APRIL–JUNE 1964

[Deposition in nc/m²]

Station and type of collection			April	May	June
Bermuda:	(Kindley AFB)	(col)	0.42	0.79	1.16
Bolivia:	La Paz	(col)	0.03	0.03	0.01
Brazil:	Belem	(col)	0.18	0.36	0.09
	Trinidade Island	(col)	0.01	0.08	0.59
Canada:	Ontario, Moosonee [a]	(col)	1.06	2.54	3.13
	Ernest Harman AB	(col)	1.27	1.67	2.22
	Goose AB [b]	(col)	—	—	—
Chile:	Antofagasta [a]	(col)	0.02	0.02	[b]
	Puerto Montt [a]	(col)	0.10	0.36	[b]
	Punta Arenas [a]	(col)	0.03	0.10	[b]
	Santiago [a]	(pot)	0.02	[b]	[b]
	Santiago	(col)	0.03	[c]	[b]
Columbia:	Bogota	(pot)	[d] 0.10	0.03	0.07
Costa Rica:	Turrialba	(col)	0.11	0.37	0.25
Equador:	Quayaquil [a]	(col)	0.06	0.08	[b]
	Quito	(col)	[c]	0.03	0.02
Greenland:	Thule [a]	(col)	0.13	0.07	0.19
Iceland:	Keflavik	(col)	0.42	0.58	2.39
Mexico:	Mexico City [b]	(col)	—	—	—
Canal Zone		(col)	0.24	0.34	0.04
Peru:	Lima [a]	(col)	0.01	0.03	0.02
	Lima	(col)	0.02	0.03	[b]
Puerto Rico:	San Juan	(col)	1.23	0.76	0.87
Venezuela:	Caracas	(col)	0.17	0.17	[b]

[a] 80th Meridian Network Station.
[b] No data reported.
[c] No data available.
[d] Proportioned from originally consolidated data.

TABLE 3.—RADIOCHEMICAL ANALYSES OF POT FALLOUT SAMPLES AT 6 U.S. SITES, HASL, APRIL–JUNE 1964

Sampling location by State and city	Fission Product and "Tracer" Radionuclides in Monthly Collections [Deposition in nc/m²]																				
	Precipitation (mm)			Strontium-89			Strontium-90			Cerium-144			Cesium-137			Zirconium-95			Manganese-54		
	Apr	May	Jun	Apr	May	Jun	Apr	May	Jun	Apr	May	Jun	Apr	May	Jun	Apr	May	Jun	Apr	May	Jun
California, Palo Alto	1.02	13.21	13.72	<0.01	<0.05	<0.02	0.05	0.22	0.12	2.20	4.21	2.04	0.15	0.43	0.14	0.05	0.09	0.08	0.08	0.15	0.07
New Jersey, Westwood	155.96	26.67	62.48	[a]	[a]	[a]	2.58	0.86	2.39	29.26	8.53	24.01	4.48	1.36	4.13	1.87	0.34	0.52	2.53	1.0	1.90
Oklahoma, Okla. City	53.34	95.0	17.27	<0.67	<0.10	<0.05	1.33	2.54	0.73	15.13	31.11	9.65	2.14	4.17	1.01	0.21	0.60	0.10	1.07	2.60	0.59
Tennessee, Chattanooga	249.68	125.48	84.33	[a]	[a]	[a]	4.40	2.11	1.43	64.85	26.36	12.97	9.65	3.26	2.52	3.34	1.04	0.49	4.01	2.12	1.26
Washington, Seattle	33.78	35.31	77.98	<0.03	0.04	<0.04	1.54	1.87	1.15	14.71	12.27	8.57	1.90	2.40	1.73	0.77	0.51	0.32	1.49	1.67	1.08
Wisconsin, Appleton	66.04	135.13	38.35	[a]	[a]	[a]	1.35	2.46	0.77	16.79	28.99	7.37	2.37	4.17	1.31	0.98	0.97	0.26	1.20	2.85	0.73

[a] No sample received

TABLE 4.—ANALYSIS OF FALLOUT FOR SPECIFIC RADIONUCLIDES, JULY–SEPTEMBER 1964

[Deposition in nc/m²]

Station	July		August		September	
	Sr^{90}	Cs^{137}	Sr^{90}	Cs^{137}	Sr^{90}	Cs^{137}
Calgary	1.22	2.10	0.39	0.76	0.43	0.64
Coral Harbour	0.53	1.10	0.76	0.97	0.31	0.58
Edmonton	1.15	2.46	1.10	1.83	0.51	0.91
Ft. Churchill	1.31	3.07	0.63	1.15	0.43	0.76
Ft. William	0.62	1.14	1.18	1.93	0.57	1.16
Fredericton	1.15	1.91	0.99	1.61	0.44	0.57
Goose Bay	2.98	3.92	0.98	1.51	0.53	0.71
Halifax	1.56	2.38	0.89	1.53	0.47	0.83
Inuvik	1.97	3.16	0.26	0.49	0.10	0.24
Montreal	1.86	3.10	0.77	1.21	0.19	0.32
Moosonee	0.95	1.49	1.41	2.27	0.90	0.82
Ottawa	1.99	3.22	0.46	0.85	0.11	0.51
Quebec	1.86	2.74	1.22	2.33	0.34	0.46
Regina	2.16	5.71	0.91	1.32	0.30	0.58
Resolute	0.24	2.36	0.50	7.08	[a] —	2.60
St. John's, Nfld	0.72	1.57	1.48	2.19	[a] —	1.06
Saskatoon	0.74	1.93	1.15	1.67	0.78	1.23
Sault Ste. Marie	0.53	1.51	0.97	1.47	0.60	1.03
Toronto	1.87	3.22	0.94	1.74	0.31	0.33
Vancouver	1.90	2.26	0.68	1.15	0.90	1.19
Whitehorse	0.43	0.98	0.71	0.94	0.23	0.43
Windsor	1.75	2.46	1.11	1.76	0.53	0.73
Winnipeg	0.67	1.81	1.07	1.78	0.29	0.51
Yellowknife	0.25	0.52	1.35	0.58	0.57	0.67

[a] No analysis.

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